Handbook of Research on

Applied E-Learning in Engineering and Architecture Education

David Fonseca and Ernest Redondo

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Handbook of Research on Applied E-Learning in Engineering and Architecture Education

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One of the contemporary society characteristics is that the amount of information available to any individual is enormous, generating problems to manipulate, assess and take the best of this information. In this case, student need to be educated to evaluate it and have skills to construct personal knowledge, developing understandings not only about the content of science, but also its methods. One of the science education challenges issues is how to stimulate active learning and develop competences in ICT-rich environments. Due to the importance of questioning skills to promote active and reflexive learning and the few studies on questioning profiles in e-learning or b-learning contexts, we propose the development of curriculum design, as well as to discuss the adequate use of strategies that could be implemented to stimulate student and teacher questioning. This chapter has the intention to also continue a deep discussion about many aspects of the epistemology of questioning in these contexts.

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Susana Álvarez Rosado, GRIAL Research Group at University of Salamanca, Spain

This chapter presents an application, Join the Board (JTB), which provides shared and collaborative work environments between digital iPhone and iPad devices through a Network of Local Area (LAN) over a Wi-Fi connection. JTB allows using two connection types in the board: an off-line board (the user has a local and individualized work) and an on-line board (the user can create sessions that each

one gives a collaborative board. All the devices that are interesting to work in this collaborative board must be joining to this session with a specific role system and start working on it). All the workflow in a collaborative board is through a turn management that is controller by a moderator device. JTB has only been developed for the family of iPad and iPhone version equal or higher than 5.1 operating system and behind using more than six design patterns and implementation. It has been developed three types of different and specific protocols that form the core of JTB application and it have been used for the encoding messages and managing the entire dialog between devices. This chapter shows a full case study that shows the potential of the functionalities.

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Lina Morgado, Laboratory of Distance Education and eLearning (LE@D), Universidade Aberta, Portugal

Over the past 10 years there has been a great evolution of technology and the way the teaching and learning process is developed, as well as how research and publication are carried out. The Web 2.0, a term coined by O'Reilly in 2004, has introduced a new concept to the use of the Internet, in particular as it relates to the educational framework. The web 2.0 tools allow the creation of emerging ubiquitous environments that enable the development and management of a real Personal Learning Environment (PLE). This chapter is a proposal for the "Handbook of Applied Research on E-Learning in Engineering and Architecture Education" and represents a literature review on the topic of Personal Learning Environments (PLE). It explores the definition around the concept of PLE, its history, the advantages for its use in a lifelong learning process and its importance in the scope of the present research.

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Over the last two decades the evolution of IT has sped up in such a way that teaching practices and learning methods have evolved. On the first hand, the motivation relies on a quick access to data for learners attending a course or during sandwich courses. On the second hand, a greater access to contents leads to a new relation between trainees and trainers (a new attitude enforced by specific pedagogy for Continuous Vocational Training). Despite some drawbacks and the generated new behaviors of the digital generation, the internet connection speed, the new devices and tools (LMS) undoubtedly stress the integration of ICT in the training model. The challenge for accessibility, good education and collective work benefits the development of innovative solutions; enforced by the Higher Education framework in Europe. But even if funds are directed for techniques, only a few efforts are given to help a new posture for trainers.

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New Literacies in the Intellectual Field of Education: Mapping Theoretical Perspectives in Scientific Publications 88
Adriana Gewerc Barujel, Universidad de Santiago de Compostela, Spain
Joel Armando, Universidad de Santiago de Compostela, Spain

This article studies the theoretical perspectives about new literacies that are dominant in the intellectual field of education at an international scale. The baseline assumption is that this is the primary field in which discourses are produced and then recontextualised (selectively dislocated and relocated) as curricular contents in teacher education (Bernstein, 1993). Our identification of theoretical perspectives is based on the analysis of scientific publications in education from 2007 to 2010. The study combines the exploration of more than 1500 texts, 70 of which were analysed in depth. The main objective was to graphically represent the different perspectives, showing the relationships within and between each one of them, as well as the agents who produce and legitimatise them. The identified perspectives and the constructed dimensions of analysis have been used in further stages of research in order to study national and regional curricular documents. This chapter reflects on what these perspectives can contribute to the field of Engineering and Architecture Education.

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Luca Argenton, Center for Studies in Communication Sciences – CESCOM, Italy
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Serious games are growing rapidly both as an industry and a field of academic research. They have been able to shape new opportunities for individual and collective learning and training, showing a discrete effectiveness. Further, serious games have been capable of supporting health and well-being. That is why they can be considered as positive technologies. Positive Technology is an emergent field whose goal is to investigate how Information and Communication Technologies (ICTs) can be used to empower the quality of personal experience The aim of the present chapter is to discuss the role of serious games as positive technology, analyzing how they can influence both individual and interpersonal experiences by fostering positive emotions, promoting engagement, as well as enhancing social integration and connectedness.

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Web 2.0 tools offer innovative technologies for learning and training, and it exists a strong pedagogical foundation to include such tools in education. As a consequence of its more widespread usage arise issues in the context of managing these cloud services, such as to create adapted instances tool resources, to assign such resources to teachers and learners, and others. Web and educational interoperability technologies have provided initial paths toward building this type of e-Learning 3.0 cloud education environments, however, fundamental challenges remain such as granular tool resources management, and the lack of use of Semantic Web technologies to leverage automatic machine-processable tool API. To overcome these issues, an holistic model for flexible interoperability is contributed in this chapter. Covered aspects

includes a semantic definition of tools' API, an interoperability service framework capable to automatically process APIs, a semantic proxy that enables usage of current APIs, and a system for learning activities orchestration using these tools. Furthermore, advanced semantic technologies to support the model for flexible interoperability are analyzed.

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Valéria Farinazzo Martins, Universidade Presbiteriana Mackenzie, Brazil

Problem-based Learning (PBL) is an instructional approach that uses a real problem to focus, motivate and facilitate learning relevant to the future performance of student conceptual, procedural and attitudinal knowledge as professional life. This paper presents and discusses the implementation of PBL teaching model in Human Computer Interaction (HCI), specifically in teaching usability evaluation of an online course. The model was applied to three classes of the HCI course, involving 16 students, a Brazilian University and 82 users. The methodology and results are presented in this work.

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Javier Carmona-Murillo, University of Extremadura, Spain
Juan F. Valenzuela-Valdés, University of Extremadura, Spain

In order to motivate the students in a Problem Based Learning environment, two different strategies are analyzed. The first one consists in introducing two crosscutting issues such as the ecology and the study of patents. In that strategy, the students need to solve the activities taking in account this "green component" to obtain the best solution as well as the study of patents (which is the process to patent something), that engineers need to know to develop their professional career. The second strategy is to analyze the motivation of students when PBL is combined with different instructional methods, different objectives and in different courses. In order to do this analysis, we have implemented different practices that includes both e-learning and m-learning. Finally, we analyze the motivation during our PBL courses through a survey. This analysis has been done in three different subjects in a Telematics engineering degree at University of Extremadura, Spain.

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Amir Manzoor, Bahria University, Karachi, Pakistan

All over the world, thousands of engineering institutions offer conventional engineering education. However, the quality of education, is a matter of concern. MOOCs (Massive Open Online Courses) permit learners to access and benefit from the teaching by renowned professors. MOOCs offer an unprecedented opportunity to revitalize education. These cause complete dis-intermediation of the university system, making them very affordable; however, they have several shortcomings in their present form. Students enrolling for a MOOC still have to conventionally study the subject for their degree. Complete absence

of physical group activities in a class room under a teacher's mentoring, is another serious issue. Conduct of practical sessions in laboratories is an important aspect of engineering education, for which MOOCs offer no alternative. This chapter reviews the state-of-the-art of MOOCs in engineering education and provides suggestions as to how MOOCs can be effectively utilized for enhancing engineering education.

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Alexei Scerbakov, Graz University of Technology, Austria
Kristina Neuböck, University of Graz, Austria

Massive Open Online Courses (MOOCs) are a phenomenon of these days. Therefore it seems just a consequent step to carry out research studies how MOOCs can be integrated best in our daily life. This work aims to describe first experiences from the implementation of two MOOCs on a new developed platform. Both courses are related to engineering education: one to physics and one to mechanics. First the concept as well as the development and then also the evaluation is pointed out. It can be concluded that there is potential for educational institutions, but also barriers which must be taken into account.

Chapter 12
Teaching and Learning Requirements Engineering Based on Mobile Devices and Cloud: A Case Study 237
Fernando Moreira, Universidade Portucalense, Portugal
Maria João Ferreira, Universidade Portucalense, Portugal & Centro Algoritmi, Universidade do Minho, Portugal

Organizations have suffered a large (r)evolution at social, economic and technological levels. The increasing number of mobile devices on day-to-day of the general population and particularly among youth people, leads to the emergence of new paradigms in several areas of activity, particularly in education. As an example of a new paradigm in teaching and learning process, mobile learning supported by cloud environments and Bloom's taxonomy could be appointed. In this paper and in the context of a course of 1st cycle, following the guidelines of courses in Information Systems provided by ACM / AIS, it is proposed the use of Google tools, aligned with Bloom's taxonomy, the model Blended Mobile Learning-Context Oriented in a Requirements Engineering course.

Chapter 13
Multidimensional Assessment of Open-Ended Questions for Enhancing the Quality of Peer Assessment in E-Learning Environments 263
Loc Phuoc Hoang, Quang Tri Teacher Training College, Viet Nam
Le Anh Phuong, Hue University of Education, Viet Nam
Somjit Arch-Int, Khon Kaen University, Thailand
Ngamnij Arch-Int, Khon Kaen University, Thailand

In online learning environments, peer assessment activities lack the observation and supervision by the teacher or instructor. Therefore, students may be lacked full effort to assess their peers. There exist the students' hesitation about criticizing their peers and scoring their peers honestly, the likelihood for peer assessment to be occasionally unreliable and unfair. The present assessment methods focus only

on the single-dimensional assessment of content rather than the activities and collaborations among the students. Students also have no chance to analyze and comment on their peer answers. This study explored the multidimensional assessment method on open-ended question to foster positive attitudes and full effort among students engaging in E-learning environments. The objectives are as follows: 1) To develop a process model for multidimensional assessment (M-DA) to enable effective learning 2) To develop free-text answers assessment by using vector space model and semantic extraction model 3) To develop an algorithm for evaluating students' based on multidimensional assessment. Two groups of parallel students taking an e-course were tested on the system. The results of experiment noted that the proposed method overcomes the method just focuses on student assessment only without consideration and evaluation of the quality of the peer assessment. In light of the findings, the proposed method actively impacted on the development and improvement of learning and the quality of peer assessment among students in E-learning environments.

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Susan Gwee, English Language Institute of Singapore, Singapore
Ek Ming Tan, English Language Institute of Singapore, Singapore
Mingfong Jan, National Central University, Taiwan

In this chapter, the authors propose to look at the empirical findings that will be useful for instructors, who wish to improve their understanding on how to design an e-learning curriculum that will take into account the different learning needs of their engineering students. The studies surveyed in this chapter will focus on gender and game-based learning, which will offer insights as to how to improve the level of participation and learning outcomes for females in male-dominated fields. In particular, the authors will focus on gender issues and how learning in an e-learning curriculum can be designed to engage female students and to improve retention of female students. The authors propose the following change in an engineering e-learning curriculum: mixed-sex groups, use of collaborative activities, blended learning, and communication tools, and mixed-sex curriculum design team.

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Learning GIS in Architecture: An Educational Experience to Improve Student ICT Skills 311
Pilar Garcia-Almirall, UPC - BarcelonaTech, Spain
Ernest Redondo Domínguez, UPC - BarcelonaTech, Spain
Francesc Valls Dalmau, UPC - BarcelonaTech, Spain

The introduction of Information and Communication Technology tools in the architectural practice can be challenging. This chapter discusses an educational approach to teach Geographic Information Systems to architecture students in the Barcelona School of Architecture. The methodology uses a combination of theory lectures, worked-out examples with faded guidance using a real-world case of study, and self-directed discovery in a project-based learning activity. The results of pre-course and post-course surveys are also discussed to illustrate the workflow of students when using spatial data, their perception on using GIS applications, and their impressions regarding the development the course. Finally, the possible reasons for the limited adoption of these tools in the architectural field are also discussed.

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Active Learning using Digital Technology and Ubiquitous Information in Architectural Construction: PBL as a Vital Methodology for Instructional Design 338
Núria Martí Audí, Ramon Llull University, Spain
Marta Adroer Puig, Ramon Llull University, Spain
David Fonseca, Ramon Llull University, Spain

In the new context of the Information Society and learning skills, architectural education through active constructive methodologies is able to form professionals capable of combining technical and aesthetic aptitudes and begin to apply to the design and building construction skills. In the discipline of Architectural Construction where contact with the professional world is inevitable. The strategic instructional design element used as main methodology the PBL. With the use of information technologies and communication, ICT and Ubiquitous information ensures the acquisition of skills and knowledge. The programming steps of PBL at the use of ICTs as tools for research-knowledge and representation -communication, achieves another educational dimension. This provides students awareness of their own learning, as also a conceptual relationship and ultimately a holistic view of architecture.

Chapter 17
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Sara Eloy, Instituto Universitário de Lisboa/ISTAR-IUL, Portugal
Miguel Sales Dias, Instituto Universitário de Lisboa/ISTAR-IUL, Portugal & Microsoft Language Development Center, Portugal
Pedro Faria Lopes, Instituto Universitário de Lisboa/ISTAR-IUL, Portugal
Elisângela Vilar, CIAUD, FA/ULisboa, Portugal

This chapter focuses on the development and adoption of new Multimedia, Computer Aided Design, and other ICT technologies for both Architecture and Computer Science curricula and highlights the multidisciplinary work that can be accomplished when these two areas work together. The authors describe in detail the addressed educational skills and the related developed research and highlight the contributions towards the improvements of teaching and learning in those areas. This chapter discusses the role of digital technologies, such as Virtual Reality, Augmented Reality, Multimedia, 3D Modelling software systems, Design Processes and its evaluation tools, such as Shape Grammar and Space Syntax, within the Architecture curricula.

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Chapter 18
The Importance of Virtual Learning Environments in Higher Education 404
Paulo Alves, Polytechnic Institute of Bragança, Portugal
Luisa Miranda, Polytechnic Institute of Bragança, Portugal
Carlos Morais, Polytechnic Institute of Bragança, Portugal

This chapter focuses on the concept of virtual learning environment (VLE), its characteristics and potentialities. We present the results of a research work conducted with a sample of 347 undergraduates from a Portuguese public higher education institution. The research addressed the issue regarding the

use of virtual learning environments within the higher education context and had the following aims: identify the VLE access frequency; assess the influence of users' computer skills on the VLE access frequency; and assess the importance and impact that students consider the VLE to have on supporting the course units they attend. In the light of the results obtained and considering the VLE used in the sample institution, we highlight that the majority of students accesses the VLE on a daily basis, no significant differences were found regarding VLE access according to users' computer skills, and the most valued aspects of the VLE were: checking exam results and receiving teachers' messages or notices.

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Like It: A Facebook E-Learning Architecture for Higher Education 426
Mary Leigh Morbey, York University, Canada
Farhad Mordechai Sabeti, Bnei Akiva Schools of Toronto, Canada
Michelle Sengara, York University, Canada

Social networking environments have become a ubiquitous part of the university experience. Accordingly, postsecondary institutions have started to consider the role that social networking can play in teaching and learning across academic disciplines. This case study documents findings from a 2012-2013 mixed-methods data collection in six graduate and undergraduate Digital Literacies and New Media Literacies courses at a major Canadian comprehensive university. It examines the pedagogical implications of adapting the Facebook platform for online collaboration and multimedia learning in blended courses, and offers a model of Facebook implementation for engineering and architecture education. Questions guiding the research ask: What is gained pedagogically through the use of Facebook in higher education courses? What are the pedagogical challenges encountered, and how might these be addressed? Suggestions based on observed trends are offered for the effective inclusion of Facebook as a beneficial pedagogical component in the design of e-learning platforms for higher education.

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Interactive Learning System for Primary Schools using Tablet PC..... 446
Asghar Ali Chandio, Quaid-e-Awam University, Pakistan
Zahid Hussain, Quaid-e-Awam University, Pakistan
Muhammad Saleem Vighio, Quaid-e-Awam University, Pakistan
Mehwish Leghari, Quaid-e-Awam University, Pakistan

The rapid development in technology has facilitated human beings in many ways such as automated home appliances, smart vehicles, smart mobile phones, and tablet computers. The uses of these tools and techniques are increasing in our daily lives to facilitate day to day work. The new trends in technology have focused on finding approaches towards improved learning techniques. Various tools are being used to integrate Information and Communication Technology in education. Tablet Personal Computers (PCs) are one of the new and innovative tools used in education for enhancing learning skills. This research has been conducted in five primary schools, where students of class nursery to class three were taught basic lessons using Tablet PC. In this research an application has been developed on android platform with easy to use interface, where the students were able to perform simple arithmetic calculations and learned alphabet of Sindhi and English languages in visual form. During the experiment, it was observed that with visual aids students understood lessons more clearly and easily.

Chapter 21
Learning Goes Mobile: Devices and APPS for the Practice of Contents at Tertiary Level 472
Ana Iglesias Rodríguez, University of Salamanca, Spain
Blanca García Riaza, University of Salamanca, Spain

Nowadays, mobile learning allows the use of mobile devices in teaching and learning practices of almost any subject or topic of interest. In this chapter, we describe a research carried out to get data about the use that university students make of mobile devices and apps for learning purposes, as most of them use mobile phones and tablets as communication and entertainment tools, but don't get benefit from these devices as educational resources, either due to lack of knowledge or to the scarce information about the pedagogical uses of these devices. The methodology followed is based on an analysis of the results obtained from questionnaires implemented to students. From the data collected, we draw a number of conclusions relevant not only to the successful development research studies like this, but also for the implementation of teaching initiatives including mobile devices and applications for improving learning processes in general.

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Foreword

Education has experienced a slow evolution in the last 10 centuries but due to the exclusion of the internet, we are now facing the most relevant and fast revolution in all aspects of the education: the classroom, the faculty, the student, the content, the methodology, and the colleagues we have for study. Research on how technology positively affects education has been done since the 90's with an exponential growth.

Main topics are assessment, online learning, ubiquous learning, technology enhanced learning, new methods to generate educational contents, learning analytics, social networks, etc. For a general specialist in this topic, there is a lack of books like this Handbook of Research on Applied E-Learning in Engineering and Architecture Education. In this Handbook the editors have chosen to publish the best proposals around the world on the previous mentioned topics. In your hands, you have views and perceptions from fourteen different countries in Europe, America, Asia and Oceania. Education is focused on people, so, it is important to take into account the different approaches between countries on education.

I want to emphasize and thank the outstanding work of the editors of the book, Dr. David Fonseca and Dr. Ernesto Arredondo, for reviewing the new innovations in this field, for offering the authors to publish Handbook of Research on Applied E-Learning in Engineering and Architecture Education, and for convincing IGI-Global to publish this collection of innovating proposals to the scientific community.

Technology never will disappear in education. Education will never disappear in human evolution.

Lluís Vicent
Ramon Llull University, Barcelona

Lluís Vicent *is a Telecommunications Technical Engineer (Sound & Imaging), Electrical Engineer, Telecommunications Engineer, Master in e-Learning and PhD by the Ramon Llull University Barcelona. Since 1996 he has been working at La Salle - Ramon Llull University, in different positions: teaching, research, technology transfer and management. As a faculty he teaches since 1996. He is the author of the book Probability (for 2n year students), Electromagnetic Waves Propagation (3th/4th year) and Image Processing (3th/4th year), and edited a collection of lectures of contents on Electrical and Computer Engineering. Since 2003, he assumes the Direction of the e-Learning Department at the School of Engineering. He has carried out research in various fields, being the principal investigator of several projects of public and private call. From his research he wrote two books: "Multimedia in Education: adaptive learning and testing" World Scientific Press and "e-Learning" (INTEH Education). Since 2003 he leads the e-Learning Research Group in La Salle, which is called actually E-Learning Institute. He has been working on the transfer of technology since 1998. Since 2003, he is the Director of the online degree programs in Telecommunications and Computer Engineering. This responsibility includes the strategic design, planning methodology, the coordination of the teaching staff, technical and administration, including the tutoring of the students. Since July 2008, he is the Director of the Open Campus at La Salle, where he manages all the online and blended degrees in all disciplines at La Salle Barcelona. This University, stablished in the European Higher Education Area, is founded with the aim of strengthening collaboration with the International Association of Lasallian Universities. In 2012 the University was officially opened and Dr. Vicent became the first President of the La Salle Open University.*

Preface

MOTIVATION

Definitely, both technology and new methods are distinctively changing the how and when of teaching practices and learning, at all educational levels. In less than a quarter of a century we have transitioned from almost non-existence of computers in classrooms, to complex networks that allow to both study and work. We have also encountered the consolidation and development of technologies that have transformed –and will continue to transform– our society, such as the Internet and mobile phones. And in the field of education, classical teaching based on lectures is being transformed into new collaborative and experimental methods based on the concept of "learning by doing". The combination of such determinants as these discussed factors are proving their effectiveness every day, with faster and better assimilation of the skills required at each grade level, and in many cases with improved motivation and satisfaction both of the student and the teacher.

These educational transformations can be seen at all levels of the educational journey. On one hand, kindergarten, elementary, middle and high schools, are increasingly incorporating these teaching methods into a particular project as a guide to learning. Through this project, various topics are taught through additional exercises, with the support of whiteboards, multimedia content and access to computers. This digitization and the use of fairly homogeneous contents has led to several social changes, many of which have gone almost unnoticed: the ongoing disappearance of public libraries and / or concentration on a few content-specific ones, a drastic reduction of physical media such as encyclopedias or dictionaries, the capability of obtaining instant results with minimal effort, and ultimately a greater independence for educating through these new digital resources. We are in a society of "Digital Natives", expert users of social networks and mobile applications from an early age, a fact that may be very helpful for the educational changes that are occurring.

On the other hand, higher education could be placed into a different context. Due to its intrinsic links between research and teaching, we can say that it is a test bed of changes and innovative educational proposals: online courses and programs; the adaptation of content and classes for mixed purposes, both face-to-face and semi or completely online; using new methods of visualization and virtual reality or augmented reality and its use in professional environments; project-based learning, direct collaborations between academies and industries to improve labor inclusion and the acquisition of collaborative skills; design of new specific laboratories in each educational environment for the formation of specific skills; adaptation of classic courses to massive delivery systems, etc.

Within the described current situation, this manual has been conceived to provide new ideas, methods and systems that allow ubiquitous work into two major areas such as engineering and architecture. Perhaps due to its educational and professional environment, in the field of engineering is easy to find all types of the already described systems. It is an area with a wide range of publications, books, refereed journals, conferences, etc., which are constantly evolving and outlining new proposals for a teaching that is increasingly less dependent on the physical space of the classroom. The current success of a college education is based on the adaptation of content and workflow to all types of students, from the classroom to blended learning and those who can follow the course from across the world.

However the world of architecture is a very different field, starting with the different educational systems established throughout the world. While in America, to name a global example, the degree of architecture has great artistic component, in Europe the degree is more focused on technical and conceptual designs of the project. In both cases, project implementation requires collaborative work with a number of engineering fields such as structural design, plant design, construction project monitoring, adaptation to urban areas, etc. In the case of Spain –where we the editors of the Handbook are from–, it is a singular degree, where to acquire the skills of the profession it is necessary to pursue a joint degree with an enabling master's degree in a single structure of 5 + 1 years. This system provides students with competences in the design of structures, facilities design and urban studies, whereas in other countries this would require two degrees: the architecture degree and civil engineering or construction engineering degrees. The inclusion of so many educational content has anchored studies in architecture in a classical system, where most of the teachers are elder, and carries on one hand a very high transfer of knowledge to the students, but on the other, almost no ability for teaching innovation and ubiquitous adaptation of materials, with little or non-existent attempts to migrate content to online training systems.

Our motivations to edit this manual are twofold: on one side lies in the organizational experience of scientific dissemination activities. In this area the publishers account for more than thirty actions as organizers of conferences, workshops, special and invited sessions, as well as co-editors of conference proceedings, special issues in indexed scientific committees and membership of prestigious conferences and journals. Among the most important conferences where they have participated include:

- ACM Multimedia Conference
  - 1st ACM SIGMM international workshop on Media studies and implementations that help improving access to disabled users (MSIADU09), Beijing (China).
  - ACM workshop on User experience in e-learning and augmented technologies in education (UXeLATE '12), Nara (Japan).
- ICME
  - Human Factors in Multimedia (HFM 2011) - IEEE International Conference on Multimedia and Expo (ICME 2011), Barcelona (Spain).
- HCI-International
  - Social and Visual Technologies: New Trends in the Improvement of University Education. In 5th Virtual, Augmented and Mixed Reality Conference, HCI International 2013, Las Vegas (NV, USA).
  - Student-centered computing: Technological innovations to improve the motivation and 3D spatial skills of the students. In 1st Learning and Collaboration Technologies Conference, HCI International 2014, Crete (Greece).

  - Open and Social Environments for e-Learning and Education Assessment. In 2nd Learning and Collaboration Technologies Conference, HCI International 2015, Los Angeles, (CA, USA).
- CISTI 2014: Local Organization of the 9th Iberian Conference on Information Systems and Technologies, Barcelona (Spain).

The main contributions on scientific publications (magazines, books, etc.), to note are:

- Guest Editor of different volumes of "Revista Iberoamericana de Sistemas, Cibernética e Informática" and "Journal of Systemics, Cybernetics and Informatics".
- Co-Editor of different volumes of UbiCC Journal (Ubiquitous Computing and Communication Journal".
- Guest Editors of special issue: "User Experience and Access using Augmented and Multimedia Technologies" in "Universal Access in the Information Society (ISI-JCR)".
- Scientific Committee Members of different ISI journals:
  - RISTI - Iberian Journal of Information Systems and Technologies
  - UAIS - Universal Access in the Information Society
  - ESWA - Expert Systems With Applications
  - IJEE - International Journal of Engineering Education
  - Arquiteturarevista
  - ACE - Architecture, City and Environment
  - DYNA
  - JUCS - Journal of Universal Computer Science

The other motivation for editing this Handbook, is our interest in performing an action of scientific dissemination of the various experiences gathered during the completion of the project developed from 2012 to 2015. It was made possible by the Fundamental Non-Oriented Research Project of the VI National Plan for Scientific Research, Development and Technological Innovation 2008–2011, Government of Spain, EDU-2012-37247/EDUC, titled: "E-learning 3.0 in the teaching of architecture. Case studies of educational research for the foreseeable future". This highly innovative project has focused on bringing new teaching strategies in the field of architecture to enable a ubiquitous work and methodologies adapted to the concept of e-learning.

In this regard, it has been decided to extend the range of studies and proposals related to both architectural education and other adjacent courses work: Construction Engineering, Urban Planning or Civil Engineering. Not forgetting any educational field related to engineering studies in general that could be useful in improving ubiquitous teaching experiences. As work objectives we set the selection of a series of chapters that explore new forms of representation, expression and engagement in any educational level, but at the same time can be extrapolated to the main areas of the manual: architecture and engineering.

HOW TO USE THIS HANDBOOK: THE ROADMAP

The 21 chapters of this handbook are classified into four sections according to their contents in the following order:

1. Generic studies
2. Engineering cases
3. Architecture cases
4. Pre-degree valuable studies

First of all we introduce the chapters' main contents for each Section.

In the eight chapters of Section 1, basic ideas, concepts and systems on different methodologies used in e-learning, or with the possibility to use in new projects are discussed.

In chapter 1 Francisle Neri de Souza talks about how one of our contemporary society characteristics is that the amount of information available to any individual is enormous, generating problems to manipulate, assess and pick the best of this information. Due to the importance of questioning skills to promote active and reflexive learning and the few studies on questioning profiles in e-learning or b-learning contexts, he proposes the development of curriculum design, and discusses the adequate use of strategies that could be implemented to stimulate student and teacher questioning as well.

Nazareth Álvarez Rosado, Francisco J. García-Peñalvo, Sergio Bravo Martín and Susana Álvarez Rosado, present an application; Join the Board (JTB), which provides shared and collaborative work environments between digital iPhone and iPad devices through a Local Area Network (LAN) over a Wi-Fi connection. Also, improves a new and specific communication protocol to manage the entire communication between devices. The paper shows a full case study that displays the potential of its functionalities.

Nuno Ricardo Oliveira and Lina Morgado in chapter 3 explore the definition around the concept of PLE, its history, the advantages for its use in a lifelong learning process and its importance in the scope of the current research.

Walter Nuninger and Jean-Marie Châtelet, talk about hybridization-based courses consolidated through LMS and PLE leading to a new co-creation of learning. On one hand, how motivation relies on a quick access to data for learners attending a course or during sandwich courses. On the other hand, a greater access to contents leads to a new relation between trainees and trainers. The challenge for accessibility, good education and collective work benefit from the development of innovative solutions; supported by the Higher Education framework in Europe.

Chapter 5 by Adriana Gewerc and Joel Armando studies the theoretical perspectives about new literacies that are dominant in the intellectual field of education at an international scale. The baseline assumption is that this is the primary field in which discourses are produced and then decontextualized as curricular contents in teacher education. Consequently, the identified perspectives and the constructed dimensions of analysis have been used in further stages of research in order to study national and regional curricular documents.

Luca Argenton, Federica Pallavicini, and Fabrizia Mantovani debate serious Games as positive technologies, where Positive Technology is an emergent field whose goal is to investigate how Information and Communication Technologies (ICTs) can be used to empower the quality of personal experience. Their aim is to discuss the role of serious games as a positive technology, analyzing how they can influence both individual and interpersonal experiences by fostering positive emotions, promoting engagement, as well as enhancing social integration and connectedness.

Rocael Hernandez Rizzardini and Christian Gütl, discuss a framework for e-learning 3.0. Web and educational interoperability technologies that have provided initial avenues towards building this type of e-learning 3.0 cloud education environment; however, fundamental challenges remain, such as granular tool resources management, and the lack of use of Semantic Web technologies to leverage automatic

machine-processable tool API. To overcome these issues an holistic model for flexible interoperability is contributed, which contains a semantic definition of tools' API, an interoperability service framework capable to automatically process APIs, a semantic proxy that enables usage of current APIs, and a system for learning activities orchestration using these tools.

A Case Study in Usability Evaluation of an Online Course by Ana Grasielle Dionísio Corrêa and Valéria Farinazzo Martins present and discuss the implementation of PBL teaching model in Human Computer Interaction (HCI), specifically in teaching usability evaluation of an online course.

In Section 2, the following six chapters describe different systems and proposals that addressed the implementation into the engineering framework.

Motivation on Problem Based Learning by Javier Carmona-Murillo and Juan F. Valenzuela-Valdés, discuss that in order to motivate the students in Problem Based Learning environments, two different strategies are analyzed. The first one consists in introducing two crosscutting issues such as the ecology and the study of patents. The second strategy is to analyze the motivation of students when PBL is combined with different instructional methods, different objectives and in different courses.

Amir Manzoor explains how MOOCs (Massive Open Online Courses) permit learners to access and benefit from the teaching by renowned professors. MOOCs offer an unprecedented opportunity to revitalize education. The chapter reviews the state-of-the-art of MOOCs in engineering education and provides suggestions as to how MOOCs can be effectively utilized for enhancing engineering education.

Martin Ebner, Michael Kopp, Alexei Scerbakov and Kristina Neuböck also discuss MOOCs in Engineering Education. Their work aims to describe first experiences from the implementation of two MOOCs on a newly developed platform. Both courses are related to engineering education: one to physics and one to mechanics.

Fernando Moreira and Maria João Ferreira in their paper "Teaching and Learning Requirement Engineering based on Mobile Devices and Cloud: A Case Study" and in the context of a first cycle course, following the guidelines of courses in Information Systems provided by ACM / AIS, it is proposed the use of Google tools, aligned with Bloom's taxonomy, to model BML Context Oriented (BML-CO) in a Requirements Engineering (RE) course.

Loc Phuoc Hoang, Phuong Anh Le, Somjit Arch-Int and Ngamnij Arch-Int explored the multidimensional assessment method on open-ended question to foster positive attitudes and full effort among students engaging in e-learning environments. The results of the experiment noted that the proposed method surpasses the method that just focuses on student assessment only without consideration and evaluation of the quality of the peer assessment. In light of the findings, the proposed method actively impact on the development and improvement of learning and the quality of peer assessment among students in e-learning environments.

Susan Gwee, Ek Ming Tan, and Mingfong Jan propose to look at the empirical findings that will be useful for instructors, who wish to improve their understanding on how to design an e-learning curriculum that will take into account the different learning needs of their engineering students. In particular, the authors focus on gender issues and how learning in an e-learning curriculum can be designed to engage female students and to improve retention of female engineering students. The authors propose the following change in an engineering e-learning curriculum: mixed-sex groups, use of collaborative activities, blended learning, and communication tools, and mixed-sex curriculum design teams.

In Section 3, three chapters clearly focused to the architecture framework where different solutions are discussed.

"Learning GIS in Architecture: An Educational Experience to Improve Student ICT Skills" by Pilar Garcia-Almirall, Ernest Redondo and Francesc Valls discuss an educational approach to teach Geographic Information Systems to architecture students in the Barcelona School of Architecture. The methodology uses a combination of theory lectures, worked-out examples with faded guidance using a real-world case of study, and self-directed discovery in a project-based learning activity. The results of pre-course and post-course surveys are also discussed to illustrate the workflow of students when using spatial data, their perception on using GIS applications, and their impressions regarding the development the course. Finally, the possible reasons for the limited adoption of these tools in the architectural field are also discussed.

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Sara Eloy, Miguel Sales Dias, Pedro Faria Lopes and Elisângela Vilar focus their paper on the use and development of new multimedia and computer aided design technologies in both architecture and computer sciences curriculums as well as in multidisciplinary work. The role of technologies such as Immersive Virtual Reality, Augmented Reality, 3D modelling software, design processes and evaluation tools such as shape grammar and space syntax in Architecture curriculums is also discussed.

Finally, in Section 4, we have included four proposals related with high school, secondary and primary levels which show the importance of new digital and e-learning methods that can be used at University level, based on our new digital native students.

Paulo Alves, Luisa Miranda and Carlos Morais, focus on the concept of virtual learning environment (VLE), its characteristics and potentialities. They present the results of a research work conducted with a sample of 347 undergraduates from a Portuguese public higher education institution. The research addressed the issue regarding the use of virtual learning environments within the higher education context and had the following aims: identify the VLE access frequency; assess the influence of users' computer skills on the VLE access frequency; and assess the importance and impact that students consider the VLE had on supporting the course units they attended.

Mary Leigh Morbey, Farhad Mordechai Sabeti and Michelle Sengara examine the pedagogical implications of adapting the Facebook platform for online collaboration and multimedia learning in blended courses, and offers a model of Facebook implementation for engineering and architecture education. Questions guiding the research ask: What is gained pedagogically through the use of Facebook in higher education courses? What are the pedagogical challenges encountered, and how might these be addressed? Suggestions based on observed trends are offered for the effective inclusion of Facebook as a beneficial pedagogical component in the design of e-learning platforms for higher education.

Asghar Ali Chandio, Zahid Hussain, Muhammad Saleem Vighio and Mehwish Leghari discuss how the rapid development in technology has facilitated human beings in many ways. Tablet Personal Computers (PCs) are one of the new and innovative tools used in education for enhancing learning skills. Their research discussed in the paper has been conducted in five primary schools, where students from preschool to primary three were taught basic lessons using Tablet PC. In this research an application has been developed on the Android platform with an easy to use interface, where the students are able

to perform simple arithmetic calculations and learn the alphabet of the Sindhi and English languages in visual form. During the experiment, it was observed that with visual aids students understood lessons more clearly and easily.

Ana Iglesias Rodríguez and Blanca García-Riaza describe a research carried out to get data about the use that university students make of mobile devices and apps for learning purposes, as most of them use mobile phones and tablets as communication and entertainment tools, but don't benefit from these devices as educational resources, either due to lack of knowledge or the scarce information about the pedagogical uses of these devices. The methodology followed is based on an analysis of the results obtained from questionnaires filled by the students.

Through the four sections and 21 selected chapters, the aim is to clarify a number of methods and proposals for its implementation, which can be perfectly adapted to all types of education, perhaps being more suitable in those in a more traditional area such as the case of architecture.

TARGET AUDIENCE

The targeted audience for this book is composed of professionals, teachers and researchers working in the fields of e-learning, interactive and enhanced learning, development, implementation, and education.

Teachers, faculty, and leaders in any architectural and engineering studies such as civil design, interior design, building engineering, urban planning, multimedia engineering, etc. Other teachers, human resource managers and trainers of subjects can adapt the content for on-line uses.

For researchers and students in the research fields of education, architecture, engineering, education technologies, instruction design, human-computer interaction, technology enhanced methods, gamification, etc., this book will be a useful reference for their research, work or study.

Designers and developers of e-learning contents and methods can learn and improve their work reading the previous experiences of other colleagues.

Acknowledgment

First, we would like to thank all the authors who at one time or another have been interested in our editorial project. Of a total of 59 proposals originally submitted, the Handbook presents 21 chapters with an open interdisciplinary approach that will allow incorporate these methods into a wide range of studies and educational proposals. Without the participation of all these authors, both those selected and those who have fallen during the process, this Handbook would have not been possible.

Without any doubt, we must also acknowledge the constant monitoring and support of Rachel Ginder, our Assistant Editor appointed by IGI Global. Thanks to the quick answers and solutions to everyday problems of this project, Rachel has allowed us to meet the deadlines with little difficulty. Without her quick support neither the publisher nor the authors could have successfully completed the work on time. Also we wanted to thank the entire team and members of IGI Global for supporting this project and successfully publishing.

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Section 1
Generic Studies

Chapter 1
Science Education with and through ICT: Curriculum Design and Questioning to Promote Active Learning

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ABSTRACT

One of the contemporary society characteristics is that the amount of information available to any individual is enormous, generating problems to manipulate, assess and take the best of this information. In this case, student need to be educated to evaluate it and have skills to construct personal knowledge, developing understandings not only about the content of science, but also its methods. One of the science education challenges issues is how to stimulate active learning and develop competences in ICT-rich environments. Due to the importance of questioning skills to promote active and reflexive learning and the few studies on questioning profiles in e-learning or b-learning contexts, we propose the development of curriculum design, as well as to discuss the adequate use of strategies that could be implemented to stimulate student and teacher questioning. This chapter has the intention to also continue a deep discussion about many aspects of the epistemology of questioning in these contexts.

INTRODUCTION

It is a common fact that the use of internet-based and/or Information Communication Technology (ICT) can promote a set of potential benefits not just to students but also to teachers. The most obvious manifestation of this importance is the improvement in number of computers for students and schools connected to the internet. In the Portuguese context the announcement of the distribution of 500 thousand laptops with Internet access for pupils in the first cycle of basic education is a signal of such an investment. The computer, called Magalhães, was the first laptop with internet access assembled in Portugal, and makes part of the program "e.escolinha" that aims to provide all children access to ICT resources (Governo Português, 2007).

More recently the Brasilian government announce the acquisition of 900 thousand tablet

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computer, but does not know exactly what to make of this technology that has just acquired (N/A, 2012), others public and private international institution follow similar pattern. This show a recurrently unbalance between two polo of public policy about ICT integration on educational background. Generally the quantitative aspect is reinforced over qualitative dimension. In the scheme below we represent some of components of this continuous.

This balance point between qualitative and quantitative dimensions is called by Neri de Souza & Mol (2013) *Pedagoware*. It is the systematic integration of some elements as hardware, software, student, teacher and content for education in interdisciplinary contexts to promotion of teaching and active learning. *Pedagoware* is the logical part or set of instructions or teaching strategies that take into account the complexity of the act of teaching and learning in different context.

Learning in virtual environments has grown fast for users, mainly teachers and students, who recognize the benefits of ICT tools for teaching and learning. Since then, teaching and learning in virtual environments has changed from eccentric experiments made by a few universities to the highest priority in the agendas of all academic centres in the world.

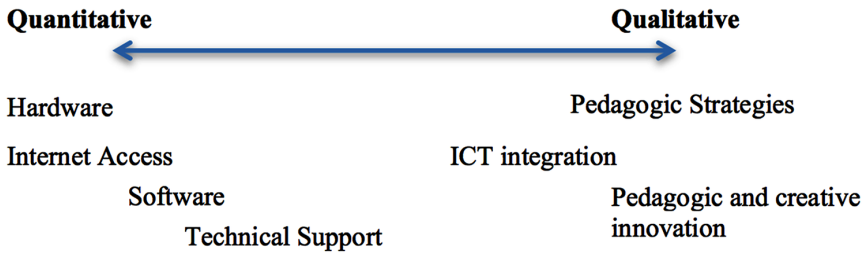
Beyond the quantitative aspect, such as hardware and software access, we need to discuss the qualitative dimension portrayed through the questions: What is the potential of ICT in Science Education? What exact role should ICT play in Science Education? To discuss the role of ICT in science education it is first necessary to identify the objectives of education in this area and then analyse if its implications are significant.

Osborne & Hennessy (2003) ask questions like: What's the main purpose of school science? To form a minority for a science-related career or to prepare a majority for active participation in a scientifically based culture? Scientific literacy is currently a widely accepted objective of science education (van Eijck & Roth, 2007). It not only involves the knowledge of key concepts in the natural sciences, but also procedural understanding of scientific inquiry.

For Osborne & Hennessy (2003) there are four common views of science education: a) *the utilitarian* (science is practically useful to everyone); b) *the economic* (we need scientifically trained individuals to sustain and develop an advanced industrial society); c) *the cultural* (science and technology are an achievement of contemporary society); d) *the democratic* (participating in the debate of the political and moral dilemmas requires a knowledge of some aspects of science and technology).

One of our contemporary society characteristics is that the amount of information available to any individual is enormous, generating problems to manipulate, assess and take the best of this information. In this case, pupils need to be educated to evaluate it and have competences to construct personal knowledge, developing understandings not only about the content of science, but also its methods (Driver, Leach, Millar, & Scott, 1996).

Figure 1.



Barton (2004) presents some facets of science teaching that can be supported by the use of lCT which are worth stressing:

- Dealing with abstract ideas and concepts;
- Visualizing dynamic processes and complex interactions;
- Experimentation and investigation;
- Pattern finding, which is, looking for the relationship between variables;
- Mathematical processing of data;
- Introduction to a large and constantly changing body of knowledge.

This author believes that ICT can enhance and improve the effectiveness of science education, but not to replace conventional approaches, and adds "Clearly, it is perfectly possible to teach science well without any use of ICT, but the question is: which aspects of the subject can benefit especially from its use?" (Barton, 2004, p.156).

McFarlane & Sakellariou (2002) state that the most powerful applications of ICT to science at the present time are the emphasis on the use of ICT to support or replace practical work as a vehicle for investigation and on the use of multimedia and the internet as a vehicle for the development of scientific reasoning. By scientific reasoning they mean "scientific thinking" and "scientific literacy", which include a rational-calculating approach. On the positive effect of ICT in science education, Cox et al. (2004) comment:

The use of ICT has a positive effect on many areas of attainment in science. The types of use of ICT and the enhancement of pupils' learning are much more closely related to specific concepts and skills ... Through the use of ICT, pupils have improved their understanding of scientific concepts, developed problem-solving skills, been helped to hypothesise scientific relationships and processes, and improved their scientific reasoning and scientific explanations. (Cox et al., 2004, p.4)

In spite of these advantages, Osborne & Hennessy (2003) conclude that "the research literature provides very little support for the popular (though perhaps unrealistic) notion of a technological revolution in teaching and learning as a consequence of introducing ICT" (p.37). However, these authors consider that the role of ICT-based research tools is a key issue because these are thought to have a *transformative potential* with respect to the aim of a *science curriculum* that contributes to the students' development of scientific literacy.

In this chapter we will discuss important aspects of ICT integration in science and engineering education. So we will organize this chapter in four structural questions: i) What can ICT offer to science and engineering education? ii) What is Science Curriculum with ICT and through ICT? iii) Why are some curriculum applications of ICT-based research tools successful whereas others fail? iv) How to develop knowledge towards effective teaching in ICT-rich environments?

Level of ICT Support (What Can ICT Offer to Science and Engineering Education?)

A classification of potential ways of supporting human activity by computer or ICT is based on the three-level structure of activity proposed by van Eijck & Roth (2007). These three levels – *operation, action, and activity* –, reflect the different organizational levels at which the collective motives of activity are realized. At the *level of operations*, computers can support activity systems by taking over operations – for example, automated into a routine in a spreadsheet (calculate arithmetical operations). At the *level of actions*, computers can be used to support transformative and manipulative actions and for making tools and procedures visible and comprehensible – for example, a spreadsheet can be used to calculate arithmetical routines while organized in a comprehensible (dynamic) sheet. At the *level of the*

activity systems, computers enable the automation of a new routine or the construction of a new tool – for example, a spreadsheet is used in the context of worksheets constructed in a research activity reflect the dimensions of the collected dataset, the applied quantitative methods, and the desired representation of the results (tables, graphs, numbers, etc).

More important here is a conception of level of ICT support use. When students use ICT-based research, all tools and strategies should support every one of these three levels of the activity.

School science is a practical subject that involves doing things, such as observing, measuring, communicating and discussing, trying things out, investigating, handling things, watching and monitoring, recording results. These are all things we see happening in the science classroom. But as much as science is a practical discipline, it is equally a theoretical subject that involves thinking, inferring, having good ideas and hunches, hypothesizing, theorizing, simulating and modeling. Thinking and thought experiments are as important as hands-on activities. According to Wellington (2000), ICT can help as much in the theoretical aspects of school science as it can in the practical ones.

This author sees science from two different viewpoints, one that involves *process* (processing data, hypothesis, communicating, etc.) and another that involves *content* (facts, laws, theories, etc.). Both are equally important and these skills and processes are vital to science itself, as well as to science education. Of course ICT can help in learning the content and process of science and school science as we can see in Table 1.

In Table 1 we added the last column to discuss the importance of teacher support in all students' active learning. The use of ICT in science education can involve many aspects and tools: word processing/desk-top publishing, databases and spreadsheets, communications, interactive media, control, simulations and modeling, data-logging, graphics, but without students' involvement in creative thinking, a reflexive attitude and active questioning supported by teachers, all teaching and learning can fail.

Table 1. Pupils' science activities and the ICT tools which enhance them

Pupils' Science Activity	What ICT Tools Will Help?	Science Teacher Support
Planning an investigation	Word processing	Motivating students' questions, training questioning skills
Researching/learning about a topic	CD-ROM, databases, tutorial programs, Internet	Orientation in selected database, tutorial programs and choice of Internet trusted source
Taking measurements	Data-logging	Orientation about taking measurements
Making results tables, Drawing graphs	Spreadsheets, Data-logging software, databases	Discuss what is the best way to show results
Doing calculations	Spreadsheets, Data-logging software	Support students in calculations difficulties
Searching for patterns	Data-logging software, spreadsheets, simulations, modeling programs	Some well thought teacher's questions to motivate other students' questions about tables and graphs drawn
Asking 'what if. . . .?' questions	Simulations, databases, modeling programs	Orientation in selected simulation software and discussion of questions asked
Comparing pupils' results (reviewing a topic)	CD-ROM, data files, Internet	Stimulation of students' questions and explanation about results with other people
Presenting information in a report	Word processing, desk-top publishing, spreadsheets	Teacher´s questions and strategies to motivate students' questions about presentations of each colleague

Adapted from Wellington (2000).

In the research conducted by van Eijck & Roth (2007), students negotiated with colleagues questions they wanted to investigate from the questions asked only by the teacher. In their conclusions these authors recognize the importance of letting students generate problems and allow them to completely control the problem solving processes, when they use ICT-based research tools to develop scientific literacy. These characteristics of authentic problem solving contexts through questioning are evident:

Entering the zone of proximal development in this way will ultimately contribute to students' ability to pose meaningful research questions with respect to the working of the IT-based research tools, and, subsequently, to develop scientific literacy while actually applying the IT-based research tools in research activity and contributing therewith to research praxis. (van Eijck & Roth, 2007, p.236)

What is Science Curriculum with ICT and through ICT?

Science curricula should prepare students carefully in the use of ICT-tools for scientific literacy and active learning. For Osborne & Hennessy (Osborne & Hennessy, 2003), this process is currently frustrated by specific guidance and support for curriculum developers in incorporating ICT effectively in science curricula, that is, linked to a pedagogy appropriate for the available ICT tools.

According to van Eijck & Roth (2007) a framework for the use of ICT-based research tools in science curricula should address students' active participation in inquiry. Several uses of ICT in science education have their focus on students' active learning in research-like activities. Such approaches commonly focus on learning science in terms of ''knowledge'', ''concepts'', and ''skills".

When considering the role of ICT in the teaching of science it is important to discuss the pedagogical model of integration of ICT in school science in articulation with the curriculum. McFarlane & Sakellariou (2002), based on the premise that the approach to science is essentially investigative, suggest a model of the iterative process of science that can be used to structure experience of science at the school level with some examples of current uses of ICT (see Figure 2).

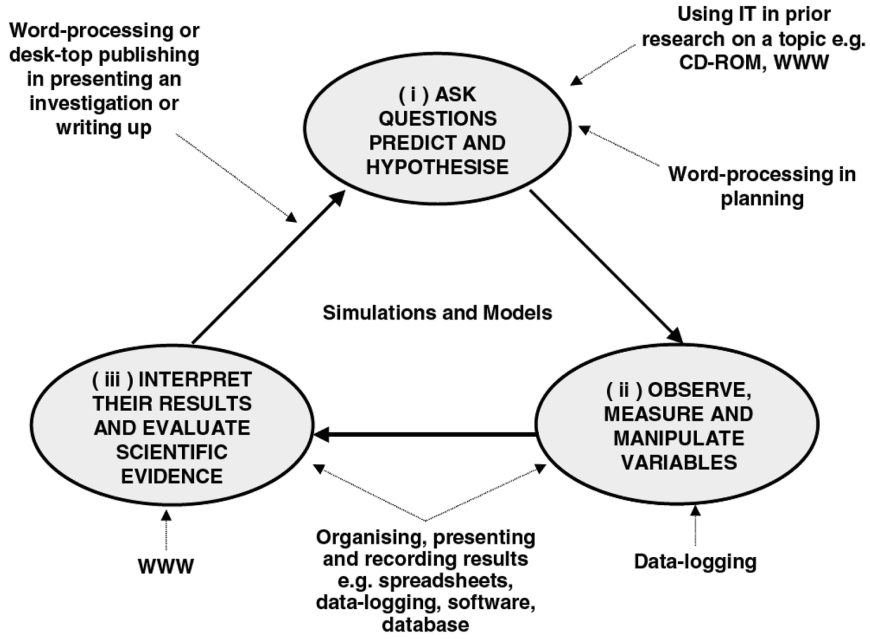
To the question "How can ICT be used to deal with some of the severe constraints on learning that the investigative model can present?" McFarlane & Sakellariou (2002) replied that this can be done either by using ICT as a tool within the context of a practical investigation, or as a substitute for the laboratory-based element of the investigation, where the model of investigation can be explored through a virtual system.

The key question for a school is: How best can lCT be deployed and managed in a school setting? According to Wellington (2000), from a school perspective, teachers need to ask, in their own working setting, which factors in their school promote and enhance lCT use in science and, conversely, which factors act as a barrier or impediment. This author cites some areas where frequent barriers arise: a) the logistics of the school, b) resources and their location, c) the role and attitude of the school ICT coordinator, d) school policies and attitudes to ICT, e) home background, e.g. home access to lCT.

Another important question is: Where is ICT best deployed, e.g. in the science lab, computer room, the library? Or where is the best methodology: taking the computer to the classroom or the students to the computer room? There are advantages and disadvantages (pros and cons) in terms of security, maintenance, integration in science activities, supervision, and environmental conditions (Wellington, 2000, 2004), but a balanced curricular structure should be fundamental for the success of teaching and learning.

McFarlane & Sakellariou (2002) consider and discuss two ways that use ICT to deal with some of the severe constraints that investigative model can present:

Figure 2. Model of the iterative process of science and ICT
McFarlane and Sakellariou (2002, p.221)



1. **Investigation with ICT (Data Logging):** Where the objective of the laboratory work is to teach the manipulation of apparatus, safe handling of chemicals, etc., clearly there is little argument to support the substitution of any virtual or theoretical alternative for hands-on personal experience. The use of data logging in schools remains a minority activity, suggesting that it remains a token rather than having found a place in routine science classes.;
2. **Investigation through ICT (Simulations Open and Close):** *Closed Simulation* – the student may be able to alter key variables, but only within an acceptable range; *Open Simulation* – it includes the generation of data within an experimental range or with a randomised element to mimic error and/ or probability.

Therefore we believe that science education with and through ICT are different dimensions that need attention from curriculum developers. van Eijck & Roth (2007) propose a way of rethinking the role of ICT-based research tools in science curricula. They propose to reconceptualise the role of ICT-based research tools as contributing to scientific literacy if students participate in inquiry activity, that is, if they have an active learning attitude.

Why Are Some Curriculum Applications of ICT-Based Research Tools Successful Whereas Others Fail?

It is easy to find in the literature that classroom applications of ICT tools are of no interest when they do not contribute to students' development of scientific literacy. In van Eijck & Roth's (2007) opinion any computer tool can be used as a research tool. Therefore, whether its use is successful or not in the classroom is not only a matter of the inherent characteristics of the tool but rather a matter of how the tool is applied within the activity.

Tiny ingredients are essential towards success, such as awareness of objectives, different levels of interactions and teacher accomplishment. Beyond appropriate tool application it is necessary that students are aware of the objectives of the inquiry. These same authors complete: "This may easily be the case when students conduct complex research activities modelled by professional science while they are not able to understand the research objectives or when the research activities focus on IT-skills while the research objectives are not made explicit at all" (van Eijck & Roth, 2007, p.235).

Webb (2005) presents and discusses some studies that focus on interactions between students and software. Where students were known to experience difficulties, software support was designed to provide active learning of concepts. For example, this author cited two studies: in the first one simulation was developed specifically to confront students' alternative conceptions in mechanics. Students' conversational interactions showed that this led to conceptual change (Tao & Gunstone, 1999); the second study was about combination of physical and virtual modelling that supported the development of conceptual understanding of organic compounds. The study showed that students in the experimental group gained a better understanding of the concept model and were more capable of defining and implementing new concepts (Dori & Barak, 2001).

Another important level of interaction is student–student interaction. The common place in literature shows that there are benefits to be gained from increasing student collaboration and from increasing student autonomy. However, student-software interactions must be approached in a student-student interaction context.

Another essential ingredient towards success is teacher accomplishment. The role of the teacher is crucial in orchestrating the active learning environment. Webb (2005) states that pedagogical practices in simulation activities or even in activities that do not explicitly make use of ICT, involved the use of focused questioning – focused questions prepared by teachers. Asking focused questions and giving students time to think about a question can become questioning in a more significant part of teaching and dialogue interaction. On the other hand, this author does not talk about the importance of questioning performed by students, especially in student-teacher interactions in an ICT context. The importance of students' questions in ICT context is focused by others authors (Almeida & Neri de Souza, 2010; Neri de Souza & Rodrigues, 2013; Neri de Souza, 2011; Pedrosa de Jesus, Neri de Souza, Teixeira-Dias, Watts, & Watts, 2003; Pedrosa de Jesus, Neri de Souza, Teixeira-Dias, & Watts, 2005).

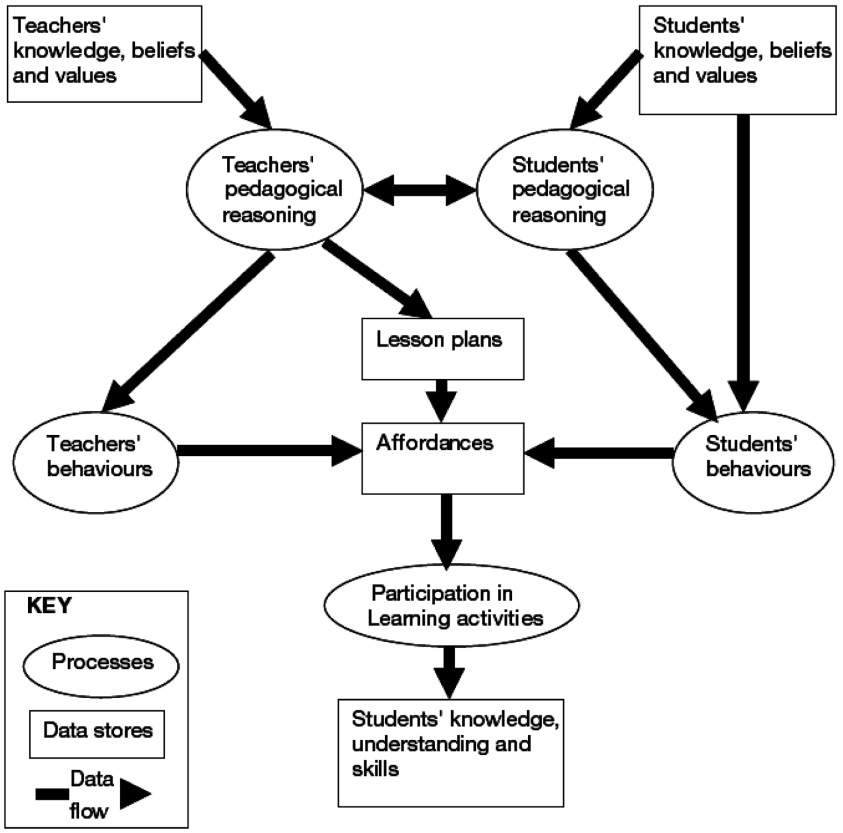
A revised framework for pedagogical practices relating to ICT use is shown in Figure 3. In this framework the importance of students' thinking about and planning their own learning is incorporated. Students may become aware not only of *what they do not understand*, but also of how they learn and what kind of materials they prefer to use.

How can teachers and students become aware of what they do not understand, preferences and learning difficulties? The answer could be through motivating high quality questioning profiles.

For Webb (2005), teachers need to know about these affordances and how to provide sufficient information about them to enable learners to use them. Teachers then need to use this knowledge of affordances together with a wide range of other types of knowledge previously identified to plan activities that will lead to learning and motivate their students. One way of improvement is "promoting dialogue between students in small groups and in whole class discussions through well-designed questioning and carefully structured tasks that enable teachers to intervene to promote thinking" (Webb, 2005, p.731).

We have clear evidence presented in the literature that teachers have a crucial role in planning the learning experiences using ICT and in promoting student learning. We agree with Webb when he says that in the future both teachers and students may be involved in the pedagogical reasoning process

Figure 3. Questioning framework for pedagogical practices relating to ICT use
Adapted from (Webb, 2005, p.727)



that leads to planning. How can students actively participate in the process of lesson planning (see Figure 2)? The pertinence of this questions is supported by Beauchamp & Parkinson (2008):

... the teacher doing the investigation at home, taking digital photographs and giving a PowerPoint presentation of the process and outcomes to the class, leaving the only active part of the process for pupils as writing down the results. (Beauchamp & Parkinson, 2008, p.116)

We believe that prior students' questions can involve them in the process of lesson planning (see Figure 2). The teacher can require that students send their own questions about a text read or other multimedia materials that will be discussed in the following class. The ICT resources can be used by the teacher to receive and consider these questions before the next lesson plan. On the others hand, students will feel that their questions are an important factor that influence a lesson.

Park, Khan & Petrina (2008) point out in their paper two major problems:

- Students' lack of engagement in science in school may translate into an unwillingness to take science courses beyond high school or pursue scientific careers.
- In Korea, the number of students who want to major in science and technology areas has decreased from 42.4% in 1998 to 26.9% in 2002.

The same is also true in Portugal. It has been found in recent years: a reduction relating to the demand for higher education in the field of Science and in certain areas of Technology (Conselho Nacional de Educação, 2007). Park, Khan & Petrina's (2008) study with Korean students suggests that Computer-Assisted Instruction (CAI) in science education can support this reform effort by contributing to the enhancement of student understanding of science concepts, particularly for boys and low achieving students. They also suggest that better educational software for students could be developed in conjunction with teachers who are familiar with methods of classroom integration and classroom models of CAI.

Many studies show that pupils' attitudes towards school science are improved in ICT-rich environments. "It is clear from the evidence that ICT has had a positive effect on many areas of attainment in science" (Cox et al., 2004, p.25). One of the conclusions of Beauchamp & Parkinson's (2008) work is that the lack of ICT in the secondary school caused some frustration, but this was mostly with the teaching of ICT, and the group remained predominantly enthusiastic about science, because previously these students had an ICT-rich primary school environment. Something indicates that this enthusiastic attitude is lasting and can help general motivation towards a science and technology vocation.

Beauchamp & Parkinson (2008) present research evidence that ICT can have a positive impact on pupil learning outcomes and on the improvement of motivation. "The literature on the motivational role of ICT is 'significant' and suggests that most pupils react favourably to the use of computers in the classroom. Thus, the potential for ICT to influence pupils' attitudes towards science at this important stage of development warrants investigation" (p.106).

Beauchamp & Parkinson (2008) in this study of the impact of the rich ICT resources on pupils' everyday life, found predominantly that these pupils perceived ICT as providing a tool for finding *answers to questions*, particularly through the internet. Although the analysis of these authors reflects the strength of these resources, nevertheless they seemed *to narrow*, rather than extend, the pupils' curiosity about the world of science.

Active Learning and Questioning (How to Develop Knowledge towards Effective Teaching in ICT-Rich Environments?)

Clark & Mayer (2003) state that the students can be educated to ask their own questions. We also believe that questioning skills can be developed in the students while they read, write, solve problems and execute practical tasks with or without ICT resources. Questioning changes the relationship between students and the multimedia material explored, because it transforms the interaction level: from viewers of information, they change to actors with an active and thoughtful attitude. Considering that the act of asking questions is dependent on the context, the strategies and instruments to stimulate active questioning need to be rethought as a function of the reality of the technologies used. We agree with Johnson (1995) when he states that "Passive Questions are those answered by the students and Active Questions are those asked by the students" (p.14).

Discussion as a method of teaching is one of the most used in online learning. One of the challenges is to keep the online discussion at levels that can promote the construction of knowledge and critical thinking. Muilenburg & Berge (2006) used discussion methods as a means of promoting constructive thinking through questions of a high cognitive level, posed by the teacher. They say that the first step to set up a prosperous environment for online discussion is to learn to ask high-level questions that provoke thinking. Accordingly, these authors claim that "when a variety of higher-order, expanding questions are used to initiate discussion, and probing follow-up questions are

employed, the discussion method can provide a forum to enhance constructive thinking" (p.9).

Strategies for teaching online that encourage, among other skills and competences, online interaction, the study of real cases, the development of projects and problem solving, have their basis in encouraging discussion which, in turn, are founded on using questioning. The big issue is how to design and manage discussion and online questioning to promote success and active learning.

Neri de Souza (2006) developed a study to create tools and strategies to stimulate students' questions in Chemistry, working with a group of first-year university students. One of the instruments used was the learning management system (LMS) WebCT, which allowed students to send questions to the teacher and colleagues, at any time, outside the classroom and on any computer with internet access. One of the results of this research showed that the use of LMS was a positive factor in stimulating questioning and was a key mean for sending more than 50% of the questions to the teacher. In this context of b-learning, computers had the role of mediation in the interaction between students and the teacher, reducing some of the social barriers that constrain the asking of questions, because it avoided the fear of being ridiculed by colleagues when presenting their questions in the classroom. In this sense, we agree with Watts *et al.* (1997) when they say that we need an environment of trust so that questions can be expressed.

Several authors agree that "questioning is a strategy to guide students to develop a repertoire of cognitive abilities, recall prior knowledge, search or inspect the learning material, identify the main ideas and concepts, make connections between them, and so forth" (Chang, Tung, Huang, & Chan, 2005, p.29). Muilenburg & Berge (2006) state that "in a constructivist learning environment, the instructor always needs to keep in mind that, when facilitating online discussion, asking the right questions is almost always more important than giving the right answers" (p.9). The practice teaching dimension in student questioning interaction is also presented by Clark & Mayer (2003) when they argue that "feedback should also be presented in text format so that learners can review their responses in relationship to the questions" (p.165).

While recognizing the importance of the act of asking questions and questioning from a theoretical point of view, in practice the ICT questioning profiles of the teachers and students are relegated to forgetfulness. Blanchette (2001) also acknowledges that there is little research on questioning in online teaching and learning environments. The deepest discussion about online questioning profiles can be read elsewhere (Loureiro, Neri de Souza, & Moreira, 2010; Loureiro & Neri de Souza, 2009; Neri de Souza & Rodrigues, 2013; Neri de Souza, Watts, & Moreira, 2008).

FINAL REMARKS

Now we have some ideas and years of use of ICT in science and engineering education, but there are still fundamental problems that persist toward a real ICT integration. We agree with Sarkar when say: "one of the most common problems of using Information and Communication Technologies (ICT) in education is to base choices on technological possibilities rather than educational needs" (Sarkar, 2012, p.30).

In this sense we discuss four questions: i) What can ICT offer to science and engineering education? ii) What is Science Curriculum with ICT and through ICT? iii) Why are some curriculum applications of ICT-based research tools successful whereas others fail? and iv) How to develop knowledge towards effective teaching in ICT-rich environments? We consider that ICT integration in science education can be synthesised in three general aims: (i) to develop digital resources; (ii) to develop pedagogical strategies and (iii) to evaluate

their impact. Therefore, the research intervention can acting at three proposes levels: Diagnostic, Intervention/Development and Evaluation.

The line of study that we present in this chapter is based on the belief that the stimulus to ask questions can contribute to a more active learning in ICT learning environments. Thus, is necessary among other objectives: i) To identify the questioning profile of the teachers and students and its role in the science curriculum with and through ICT-rich environment; ii) Understanding questioning profile evolutions from primary to secondary science schooling levels and their relationships with active learning and motivation attitude towards science and technologies; iii) To investigate the teachers' questions as a source of encouragement of students' questions in ICT context; iv) To design a science curriculum and apply strategies that could be implemented to stimulate high level questioning in ICT-rich environments; v) To develop guidelines and multimedia tutorials to support questioning in science teaching and learning; vi) To create a teachers and researchers network (multidisciplinary team) to discuss advantages and pitfalls of ICT teaching practices and exchange experiences about students' development of eQuestioning skills; vii) To develop digital resources, for students and with students, such as simulations, animations and digital video to promote active learning in science education; viii) To evaluate the impact of the conceived didactic resources and strategies in students (science learning) and teachers (professional development); ix) To create assessment tools to evaluate all digital resources developed.

Naturally, all this aims centred on eQuestioning and active learning in science education is a work that implies many research's skills and competences of a multidisciplinary team. On the other hand is necessary time and perseverance to ICT integration process can be a reality. In Biggs (1999) words: "as students learn, the outcomes of their learning display similar stages of increasing structural complexity. There are two main changes: quantitative, as the amount of detail in the student's response increases; and qualitative, as that detail becomes integrated into a structural pattern. The quantitative stages of learning occur first, then learning changes qualitatively" (Biggs, 1999, p.37).

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KEY TERMS AND DEFINITIONS

Active Learning: Teaching and learning strategy focused on action, thought and responsibility of students.

Curriculum Design: Structural plan that explore instruction process to academic, social and citizen purpose.

ICT Integration: Complete and transformative application of technology on education.

Pedagoware: Is the systematic integration of some elements as hardware, software, student, teacher and content for education in interdisciplinary contexts to promotion of teaching and active learning. Pedagoware is the logical part or set of instructions or teaching strategies in digital technology context.

Questioning: Competence that involves creative and critical thinking process of link what is known and what is not known to improve knowledge.

Science Education: Field that study and apply teaching and learning process to create thinking citizens through science knowledge.

Student's Questions: Active questioning in learning interaction.

Teacher's Questions: Passive questioning in learning interaction.

Chapter 2
Join The Board:
A New Way of Collaborative Learning

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ABSTRACT

This chapter presents an application, Join the Board (JTB), which provides shared and collaborative work environments between digital iPhone and iPad devices through a Network of Local Area (LAN) over a Wi-Fi connection. JTB allows using two connection types in the board: an off-line board (the user has a local and individualized work) and an on-line board (the user can create sessions that each one gives a collaborative board. All the devices that are interesting to work in this collaborative board must be joining to this session with a specific role system and start working on it). All the workflow in a collaborative board is through a turn management that is controller by a moderator device. JTB has only been developed for the family of iPad and iPhone version equal or higher than 5.1 operating system and behind using more than six design patterns and implementation. It has been developed three types of different and specific protocols that form the core of JTB application and it have been used for the encoding messages and managing the entire dialog between devices. This chapter shows a full case study that shows the potential of the functionalities.

INTRODUCTION

Information and Communication Technologies (ICT) are an essential part of today's Society and have impact on almost all aspects of life. The rapid advance of ICT is flooding the modern world with implications for each of the branches of modern society by providing worldwide more and more advanced and powerful technological devices that open up new fields of innovation, provide opportunities to achieve higher development levels and reduce many traditional obstacles, especially those related to the time and distance.

The generation of smart mobile phones, which has flooded the technological consumer market in recent years, has given way to the tablets and

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touch tablets. These tablets are equipped with much more capacity for processing, communication and size than smartphones (Conde, Álvarez Rosado, & García Peñalvo, 2011; Conde, García-Peñalvo, Alier, & Piguillem, 2013; Conde, García-Peñalvo, Alier, Casany, & Piguillem, 2013).

The impact these technological devices have caused, with so good acceptance by the users, has led to the development of applications for this type of device to trip because that was considered a great success from the point of view of their marketing.

On the other hand, Computer Supported Collaborative Learning (CSCL) (Bruffee, 1999) is a strategy of teaching and learning that builds knowledge through a collaborative work supported by technological resources (Alonso de Castro, 2014; Sánchez Prieto, Olmos Migueláñez, & García-Peñalvo, 2014a, 2014b).

It is precisely in this context of technology and collaborative learning where the project Join the Board (JTB) merges (Álvarez Rosado, García-Peñalvo, Bravo Martín & Álvarez Rosado, 2013), an application developed for the families of iPad and iPhone devices that pretends to be a real technological platform that provides shared work spaces shared by a group of people in which to develop activities in a collaborative way.

Although JTB was born from the will to integrate the use of new technologies in teaching practice, it is not limited exclusively to this environment, but has a place in many and different areas of society, from the field of education, passing through the business world and reaching any task (whatever type that is) that needs interaction and collaboration among different people.

The application has been developed in the framework of a project of the degree course of Engineering in Computer Science at the University of Salamanca.

Following sections of this paper will explain in detail a complete description about the functional application. Also will present the Join The Board graphic user interface and then present a simple and complete case study. Finally, paper explains all the important aspects of JTB development like planning, design pattern, communication protocol, etc.

FUNCTIONAL DESCRIPTION

JTB is based on simulate digital boards that offer participatory workspaces to all devices that are connected. Each board is managed by one of the participants who has the role of moderator and that arbitrates access to the same for scripture through a shift system.

This functionality is achieved through the development of a complex protocol of communications and synchronization among devices. This protocol consists of a dialogue based on the passage of messages that are exchanged by all the users of each board on the basis of a Wi-Fi connection required for the operation of the application in collaborative mode (online).

JTB also allows the option of using a board locally based (offline), used as a single device and keeping all its functionality without the need for Wi-Fi connection. This allows local and individualized work to the user where there is no moderator. This operating mode is always available in the tool.

In the Figure 1 shows a general overview of the operating modes that presents the app JTB.

From a general point of view devices can create two types of boards:

- **Public Boards:** The same access is permitted to all users.
- **Private Boards:** Access to them is restricted by the use of a password.

Each device can only create a board at the same time or join one of the available boards, already created by other devices. The list of accessible boards, together with its characteristics, is shown in the main session of each device, as shown in Figure 2.

Figure 1. General description of the JTB

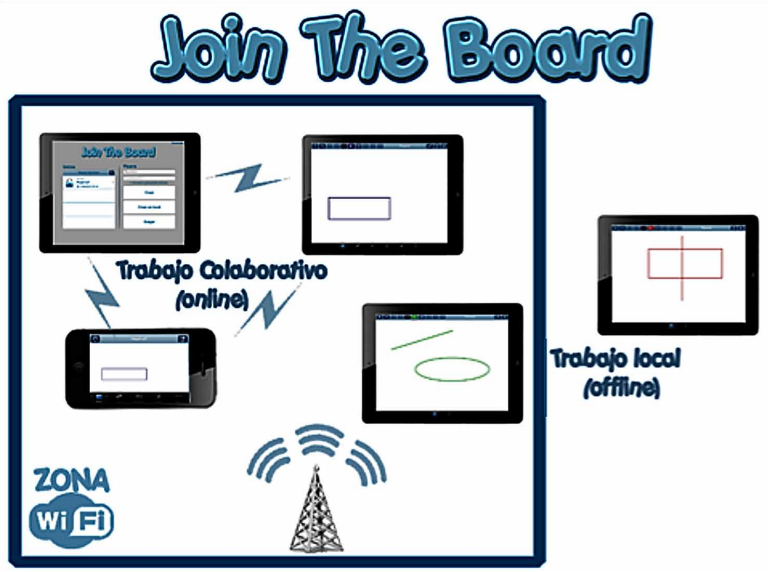


Figure 2. Screen with the list of available boards JTB system startup

Once the user has created or has joined an available board, you can take two different roles:

- **Moderator:** Initially is designated moderator automatically the participant who created the board. The application allows the change of moderator to another device attached to the board. This participant initially has the writing permission on the board and the ability to manage the shift from access to the same list, so yields control of writing to one of the participants who has requested the shift.
- **Participants:** In principle are all users attached to the board. You will see the contents of the board and the changes that are taking place in real time. When they want to participate and write on the board they must request their turn and wait until the moderator grants it to make changes. At

some point they can become moderators by delegation of functions of the current moderator.

The application is responsible for managing all communication and synchronization which takes place among different devices that participate in each board, in a way that allows at each time a shared, fluid, efficient and consistent workflow. Therefore, in the application you must start and log. For the management of communication among devices there is a management shift that is processed through the moderator. Users of the application should request and release the shift to have writing permissions on the board and at the same time, the moderator should delegate the shifts at his convenience.

JTB supports two languages: Spanish and English. In addition, application provides some basic functionality such as drawing tools:

- Select the color and thickness of the stroke.
- Select an object.
- Select shapes: line, rectangle, circle, ellipse and free drawing. You can also select text.
- Delete an object.
- Move an object.
- Scaling an object.
- It also expands its functionality to the connected users leaving the possibility of:
- Using a private chat for the participants.
- Configuring the profile user and the board, being able to assign the role of moderator to another participant.

Two features that are used to import and export the work done are attached to provide greater flexibility to the board. The export is carried out in three different ways:

- By electronic mail.
- An image .png stored in the library of photos of the device.
- By storing work in a local file on the device. In this way facilitates the resumption of any work that has been left incomplete.

Import that is allowed in the application may be in two different ways:

- By importing an image.
- By importing locally stored boards on the device.

For work in collaborative boards (JTB) there must be a Wi-Fi network that is connected to all the devices that wish to interact with the application. At least for a minimum functioning of JTB in a collaborative way, two devices must be connected. On the other hand, if you want to work in local mode, only a device participates.

JTB integrates with the Twitter social network so that the application users can interact during the workflow.

In addition, the application provides other features that complement the use of boards as, for example, put at the disposal of the participants a private chat room for each board.

The application is developed for the family of iPad and iPhone devices and is compatible with those using versions of operating system iOS equal or higher than the 5.1. Taking into account different technical characteristics that exist between both devices and taking as the largest screen size difference, certain functionality will have to be restricted on the device with the screen smaller (iPhone):

- **iPad Devices:** Will have all the features active.
- **iPhone Devices:** Behave only as listeners of the workflow shared due to its small proportions to be able to interact correctly and effectively with tapestry work, so they cannot actively participate in the design of the board. They may not create local boards due to limitations in the size of the screen.

Board Modes

Join The Board allow two different ways of work: an on-line mode and an off-line mode.

On-line mode consists on create a collaborative boards and join it between at least two devices in the same network. The protocol in this mode supports create some collaborative board in the same network. This fact gives a JTB application a major diversity of collaborative work at the same time. Also this way can allow that other devices join it when the collaborative board has already begun. If a device connects into a collaborative board when it has already begun, automatically the JTB application downloads the workspace into the new boar device. Immediately this new participant device can works on the collaborative board.

On this work mode JTB allow that the moderator device leave the board when it has already begun without lost the workspace. This moderator device gives its role to other device and leaves the board. With this fact, the context of the board isn't lost.

Off-line mode consist on create an individualized board in a device without network connection. This mode allows work in a local board to realize new boards or works that they can import to in a on-line mode boards.

Graphic User Interface (GUI)

To access to the JTB application it is only necessary to have it installed on devices that are going to be used.

It is important to highlight that, due to the differences in size between the two types of devices, different interfaces have been designed for each of them. Despite being different, they maintain the same structure of objects, so the two interfaces are as similar as possible to facilitate the work of users and that the use of the application in more limited devices cannot be seen conditioned by technical restrictions.

Figure 3 shows the different pop-up menus that can be observed in drawing and management of shifts of the board on an iPad device with settings in Spanish language.

Figure 4 shows examples of different features of the JTB application for iPhone devices with language setting in English.

Case Study

This section shows an example of JTB application that is perfect for a Math class at a school.

Teacher can work on an exercise doing the following steps:

1. Make the board (offline mode).

Teacher must create and develop the exercise on local board and export it on device. This is made in an offline mode, because only the teacher works in the board. So, in this mode only allows draw on the board, export and import the board. Other functionalities like turn management are disable.

For example, Figure 5 shows an example of collaborative work on the board. The exercise bases on solve a simple geometry problem that consist of join the geometries shapes with their areas.

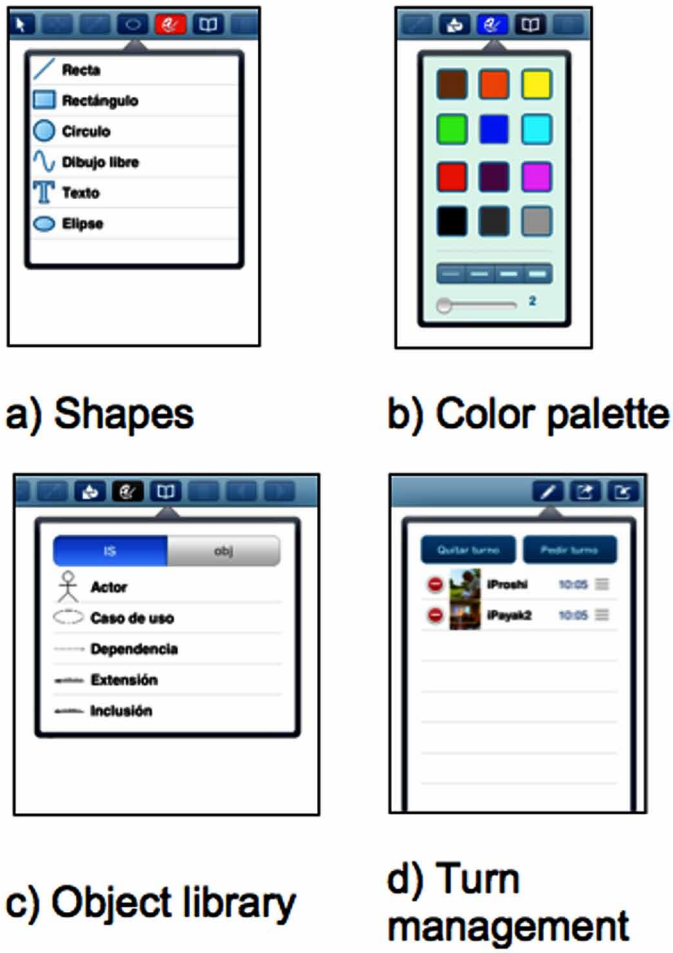
2. Publish the private board (online mode).

Teacher creates a private board and then appears on all users devices that are connected to the main session. Teacher is the board moderator. Figure 6 shows the available board. This list presents some board characteristics:

- On top can see the created board name.
- In the middle can see the board name.
- In the bottom can see the date of the created board.
- On the left can see a lock that denotes a private board.

Teacher imports the developed board (step 1) and wait for the users connections.

Figure 3. JTB Popup menus in a board for iPad devices in Spanish



3. Join the board.

The users who want to join the board are needed to select the board at available boards list. Then the teacher checks to connection of users in the list of participants are available. Figure 7 shows all participants that are connected to the created board (step 1).

4. Work in the board.

Participants request the turn access to write on the board. Always that a user has write permissions he must release the turn correctly. By other hand, the moderator delegates the turn access to the board following his own opinion. See Figure 8.

This process repeats until complete the exercise or when moderator decides, see Figure 9.

5. Close the board.

Participants can save the board with the solved exercise by three different ways (see Figure 10):

- An electronic mail.
- An image .png stored in the library of photos of the device.
- A storing work in a local file on the device.

Figure 4. JTB Screenshots for iPhone devices in English

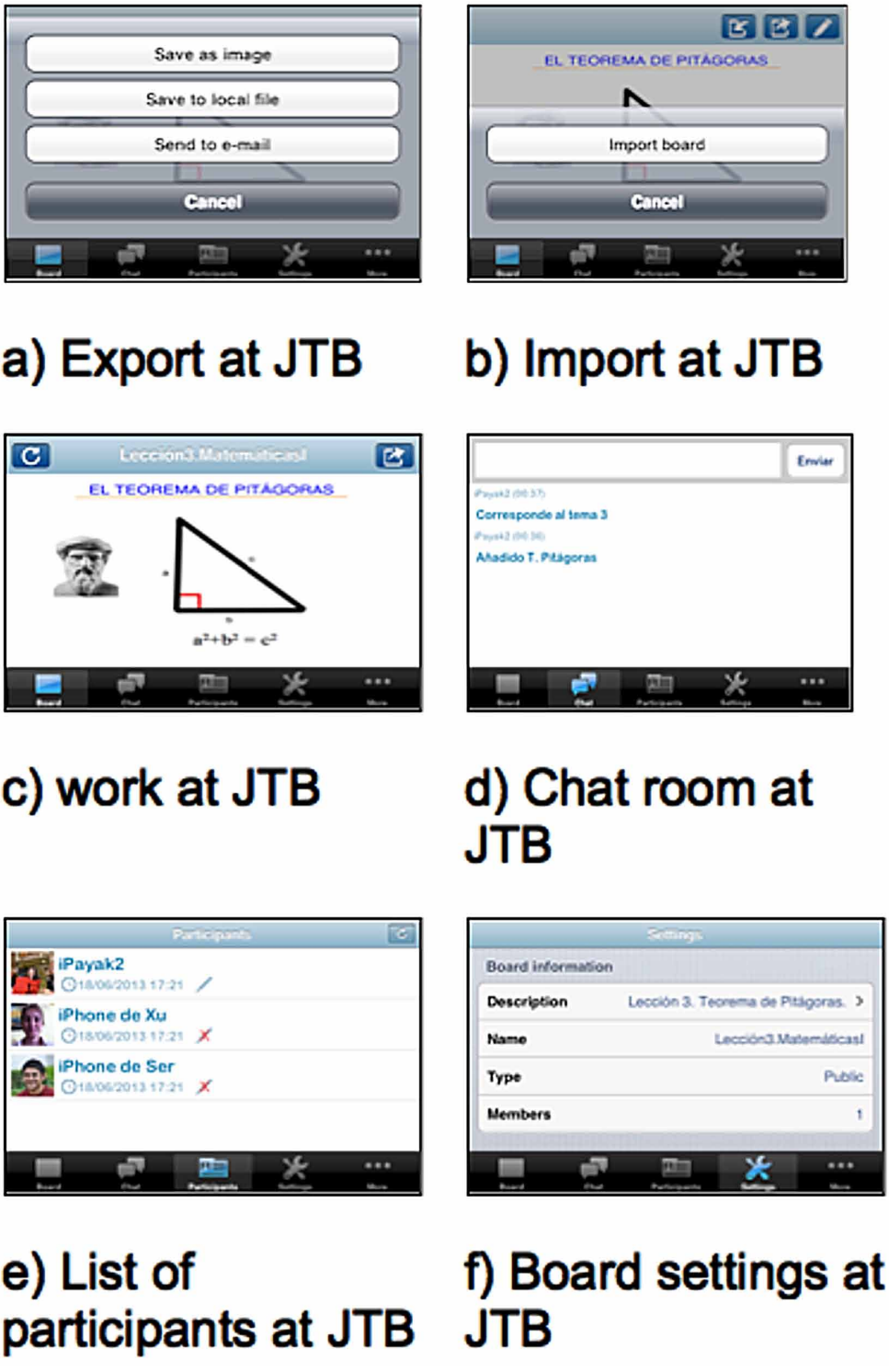


Figure 5. Example of collaborative works at Join The Board

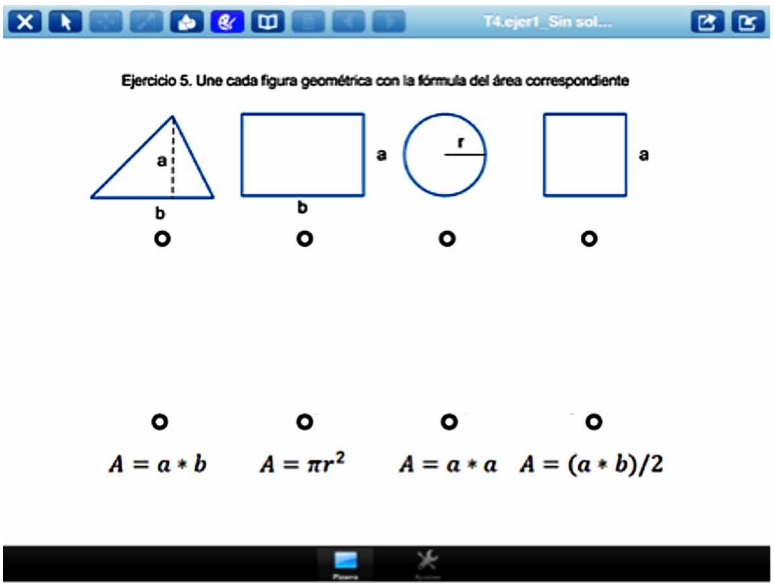


Figure 6. List of available board at users devices

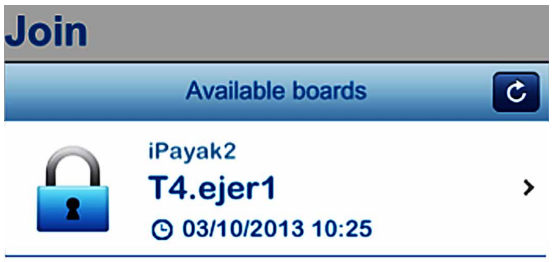


Figure 7. List of participants at JTB

By other hand the moderator changes the board name to don't overwrite it and exports it by the same way that the participant. Also the moderator can save it and, if he wants, publish the resolved exercise on a blog class, on a learning platform or a social network.

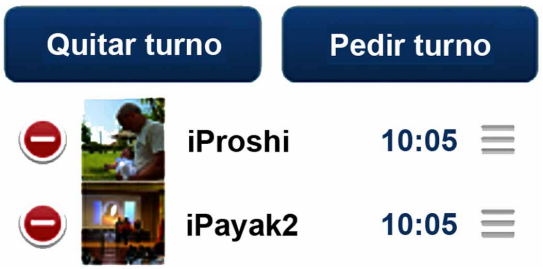
Once saved board all participants (included moderator) leave the board.

More examples can be displayed via the website http://jointheboard.grial.eu/.

Relevant Aspects of the Development

The project is planned on the basis of the Unified Process (Jacobson, Booch & Rumbaugh, 1999) through an agile approach (Garzás, Enriquez, & Irrazabal, 2012) with influence of SCRUM (Schwaber, 2004). This choice is due to the need to incorporate changes in the project quickly and independently of the stage of development that is.

Figure 8. Turn management



Specifically, 8 sprints of 30 days each have been completed in which have been added are the different functions of the application. Each sprint was composed of four phases specified by the unified process and each stage had a heterogeneous workload based on the objectives of the sprint.

From the architectural point of view of the system, there have been used more than half a dozen design patterns and implementation (Gamma, Helm, Johnson & Vlissides, 1995), highlighting two of design (Peer-to-Peer and Broker), taken as the basis for the application. The use of Peer-to-Peer pattern is that the application is a network of devices in which all operate with the same role. You could say that each node acts simultaneously as client and server with respect to other nodes in the network. This pattern is used to be able to share and exchange information directly between two or more nodes. On the other hand, the Broker design pattern is the component responsible for completing the communications between the different nodes of the network.

In relation to the coding of the application, they have had to devise, implement and document three types of different protocols that form the core of the JTB application.

- A first Protocol of encoding, which allows you to send and receive objects of JTB, due to which the programming language used only lets you exchange messages in their own language-specific objects.

The process of encoding objects has been to announce to the language that the object that is to be transferred is known. This is done encoding two methods that make the functions of serialization and deserialization of each object. So, before sending an object, it is necessary to serialize it

Figure 9. Solved example of collaborative works at Join The Board

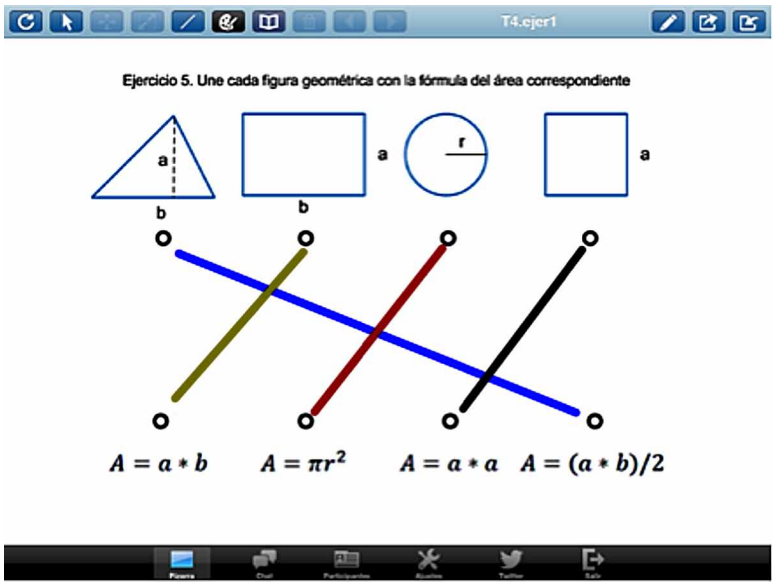


Figure 10. Export at JTB

and, on reception, prior to use, it needs to perform the opposite operation of deserialization. This Protocol has had much relevance, since it has been a part of the process of implementation of the communication of the application protocol.

- The second and third protocol was been made to manage all the devices communication and all devices synchronize. Each moment, this allows a shared workflow fluid, efficient and consistent.

The division of two protocols to manage all devices due to decrease the network traffic in several moments. Also, this fact was made that the data packet are more organized and centralized depended on its functionality.

A second communication protocol is that which is responsible for managing communications and synchronization of the devices in the main session. It consists of 5 types of different messages.

Those messages consist of:

- **PacketTypeBoardAvailable:** You must send this message when user builds a board. It publics the created board like available to all users and send all information about it.

All users receive this message. Automatically they must reload them board lists added the (new) received board information.

- **PacketTypeBoardListRequest:** Message sends to all users when user device wants to reload the available board lists.

Only the moderator role responses that message who sends a message *PacketTypeBoardAvailable* with all information about the board. This message uses to confirm that the available board is on.

- **PacketTypeBoardIsAvailable:** Message sends from the user to the board moderator. It contains all the available connections depended on a public board or a private board.

The moderator role receives that message and processes all the sent information. If it allows coming in its board it must send a*PacketTypeBoardReady* message to the user that sent the connection request. If the access to the board is denied, it sends a *PacketTypeBoardInvalidPass* message.

- **PacketTypeBoardReady:** Message sends from moderator role to user. With this message, the moderator allows the user join (it) the board.

The user receives this message and acknowledges the access to the board.

- **PacketTypeBoardInvalidPass:** Message sends from moderator role to user when it denies the access to the board because the user introduces an incorrect password to join it.

The user receives this message because it introduces an incorrect password to join the board.

A third protocol is responsible for managing communications and synchronization of devices at the session of the board. It is composed of 20 types of different messages.

Those messages consist of:

- **PacketTypeSendMessage:** Message sends to all participants of the board. This message has a text of the chat room.

All the participants receive the text message about chat room. All of them reload the received information on their chat room.

- **PacketTypeSendData:** Message sends to all participants. It has one or more board object. This message sends to them when some participant paints something new on the board.

The rest of the participants receive this message. They reload their vectorial objects list. Then, they repaint the board objects to show all the new information.

- **PacketTypeTurnRequest:** Message sends to request a turn to write on the board. The participant sends this request message to moderator.

The moderator receives this message and reloads his turn list with the new request.

- **PacketTypeTurnConfirm:** The moderator sends this message with the user identification to all participants of the board when it selects ones of its turn list to give it.

All participants of the board receive this message. They receive the participant identification who is going to have the turn. That participant, who has the turn, turns on the painting tools. The other participants reload their turn list with that who has the turn at this moment.

- **PacketTypeTurnRelease:** Message with two connotation

The first is when the moderator sends to participants to releases their turns immediately because he wants the turn. All participants receive this message and free their turns instantly.

The second is when the participant sends this message to communicate that it releases its turn. The moderator receives this message, reloads its turn list and recovers the turn.

- **PacketTypeTurnList:** The moderator sends to all participants this message with the turn list at this moment. Whenever there is a change in the turn list the moderator sends it.

All participants received this message with the turn list, reload it and show it on the device.

- **PacketTypeTurnInformation:** The moderator sends this message to the participants. The message is about the participant who has the turn. Whenever there is a change in the turn the moderator sends it.

All participants receive this message with the participant who has the turn, reload their turn list and show it on the device.

- **PacketTypeRefreshRequest:** The participant sends this message to the moderator when touch the reload button of the board taskbar.

The moderator receives this message and reloads the board. This message needs to send all the board objects to all participants through *PacketTypeRefreshResponse* message.

- **PacketTypeRefreshResponse.** The moderator sends this message to the participant who has request reload the board.

The participant receives it, reloads all the board objects and repaints it.

- **PacketTypeNewModerator:** The moderator sends it to the participant to change to moderator role.

The participant receives it, changes its role and sends to all participants its new role.

- **PacketTypeNewModeratorChange:** The moderator sends it to all participants to announce a moderator change.

The participants receive it and reload all the moderator variables

- **PacketTypeConfigurationChange:** The moderator sends to all the participants to announce a change on the board configuration.

The participants receive it and reload the configuration profile.

- **PacketTypeUserProfileRequest:** This message requests to reload a participant profile

The participant receives it and response with the information through PacketTypeUserProfileResponse message.

- **PacketTypeUserProfileResponse:** The participant sends this message with its profile to the other participant who requests it.

The other participant receives it, reloads this profile and shows it on the device.

- **PacketTypeRemoveDataIndication:** The participant deletes one board object and sends to all participants this message to communicate it.

All participants receive it, reload their object list and show them on the device

- **PacketTypeChangeDataIndication:** The participant changes one board object and sends to all participants this message to communicate it.

All participants receive it, reload their object list and show them on the device.

JTB boards are working with vector objects that have specific characteristics of the application. Each object that you can draw in Join the Board has its own characteristics based on their nature. The application maintains a list of vector objects for each board so that each object can be treated with different operations available on an individual basis.

They have had to design algorithms for selecting, moving and scaling of objects:

- Algorithms for the selection of vector objects of board have been designed so as to allow a small margin of error. This is because, by the nature of the iPad and iPhone devices, it is very difficult to guess to perfection at the point of the desired object. So that would be easier to make different algorithms for all types of ways of drawing (straight lines, text, rectangles, circles, ellipses, free drawing and images) most were treated as if they were contained in an imaginary rectangle.
- The algorithms created to carry out the movement of the individual objects are designed so that they simulate the movement of the rectangle that contains them. Not to hide the figure that is going to make the move, the lower left corner of the object has been taken as a reference point for the movement. This corner will be highlighted by the insertion of a square, which will disappear during the movement, to have greater vision and precision when it comes

to move an object to the desired place of the screen.

- The algorithms created to perform scaling of the individual objects are designed in such a way that it be allowed to scale the object from different points, once it is selected. By default, the reference point, which is taken to scale the object, is the bottom left corner to the rectangles. This point will be highlighted, as in the movement of objects, by the insertion of a square that will disappear during the scaling, to have greater vision and precision at the time of the operation. Scaling an object is completed allowing the user to change the reference point, depending on the type of object to be treated.

Finally, we have to note that the JTB application use three file types:

- proflie.dat
- Name of the board.text
- Name of the board.bin

These files store and retrieve the information that must be interpreted with the Protocol of encoding that is detailed above.

The first used file is a profile.dat file that stores all the information relative to the user profile. In order that the user, whenever you use the application, does not have to modify his profile, they will automatically load the last profile used. The user data, which are stored, are threefold:

- The call sign name of the device
- The type of the device
- The avatar associated with that device

This file is loaded whenever the JTB application starts to pick up the profile of the user data. Information is updated when there is a change of avatar in the settings panel. If for the first time you access the application, this user profile file does not exist and is created with the name of the device and an avatar by default. It is stored in the space of the device associated with the application.

The data that are stored in this file are:

- The name of the board.
- The description of the board.
- The date of creation of the board.

Associated with this, is the third file, which is called just like it, but with .bin extension, i.e. name of slate.bin. This file contains all the objects of the board. This file is paired with the former.

Both files (second and third) are created when exporting a local board and will be stored in the space of the device associated with the application. Its contents cannot be modified. Only the moderator can delete it through the import of a local board panel, and then by selecting delete or by accessing the panel's charge of a local board.

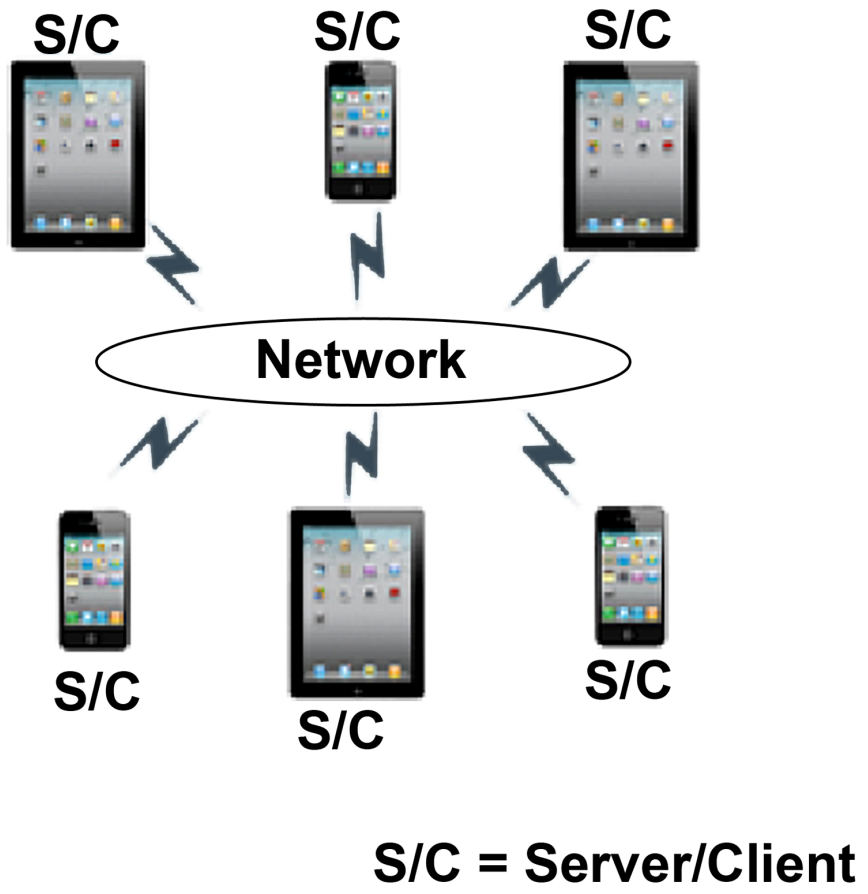
Peer-To-Peer (P2P) vs. Server-Client Architecture

Both architectures are a science computer structure that allows connecting some computers, at least two, and sharing resources through the network (Internet). So, all the information is available to all computers of the network. There architectures use a TCP/IP protocol to the network connection.

Due to the similar functionality, it was studied the most important characteristics for both architectures with the proposal to find the best choice to Join The Board.

- To a peer-to-peer architecture (see Figure 11) the most important characteristics are:
  - The computers have two different operation modes:
    - As a server
    - As a client
  - A computer can switch this two operation modes indistinctly.

Figure 11. JTB peer-to-peer architecture



- To use this architecture only is needed two computers, without matter the operation mode.
- All the information is saved into each computer.

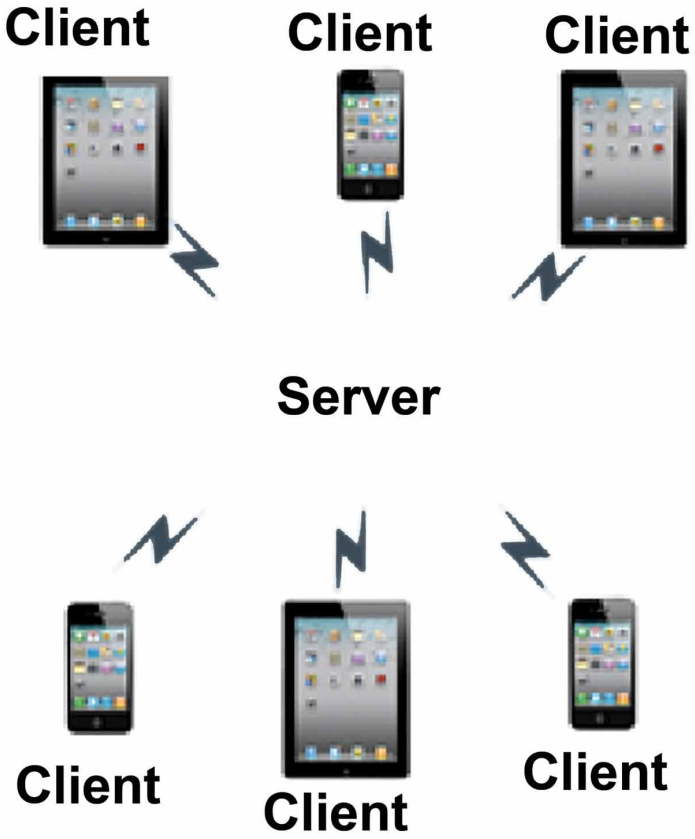
- To a server-client architecture (see Figure 12) the most important characteristics are:
  - The computers have two different operation modes:
    - As a server
    - As a client
  - A computer can use only one of these operation modes.
    - A server who responses all the customer requests.
    - A client who does request to the server.
  - To use this architecture always must exist at least a server and a client to complete the communication process.
  - All the information is saved into the server.

At the beginning, Join the board wants to be a collaborative workspace where all devices can communicate themselves without matter whose connect them.

However, after research of these two possible architectures, was thought that the peer-to-peer architecture was the best to Join The Board because it was the most simple an easy to use in these cases:

- From a functional point of view, JTB must be connected with all devices by the same

Figure 12. JTB server-client architecture



way without operation mode (client or server) because all devices must participate to the board without limitations. The peer-to-peer architecture allowed it but the server-client architecture always needed an operation mode, as a client or as a server, in each device that limited its functionality.

- From a network-traffic point of view, it was thought that all the devices must connect themselves directly. It mustn't exist a central device, like a server, that received all the device requests. This way generated a lot of network traffic because if for example, a client wants to write on the collaborative board must do three steps:
  1. The device o client must request to the server to write on the board
  2. The server responses to this device and saves the new information about the board.
  3. Each connected device must request the new information wrote on the board

By other way if JTB used the peer-to-peer architecture it only wanted two steps:

1. The device writes on the collaborative board
2. All the connected devices update all the new information about the board.
   - From a resource and network connection point of view, in server-client architecture always needs a server and a client to begin the communication. But in the peer-to-peer architecture

only needs two independent devices, each one as a server and as a client. This architecture doesn't depend on any additional infrastructure (server).

iOS vs. HTML5

After a research of the native application and HTML5 web application, in which was study the pros and cons of the use them.

- The native applications are applications that are developed to be installer on a specific platform, like iOS, using a specific software developer kit of this platform. All application characteristic depends on the platform where the application has been develop.
- The HTML5 web applications are applications that are developed to be use in a mobile browser. These applications are used in many platforms. The characteristic of a web application depends of the browser characteristic that you use.

Join The Board is a native application for the platform iOS. With this decision is wanted to take advantage of all libraries with some functionality that the software development kit has. Also, these native applications are more robust because they use the libraries of the specific platform and these libraries have been support a lot of test to be in the market. In fact, these applications offer faster performance and access direct to native device services. At last, a native application gives more security than the HTML5 web application, because all the information is protect with the same security of the device. However in HTML5 web applications, cache data or encrypted data in this language are difficult to protect them. In this language is so easier access to the code and corrupt it.

CONCLUSION

Join the Board aims to be a tool of support to teaching or any task that requires a collaborative work between two or more people. It should also be noted that JTB allows the possibility of working in local and individualized manner. This option allows you to create a new task that can be used in a future or even modify a task stored in the device.

One of the advantages of the application is that it allows import and exports work performed when working with boards in the future or to save it. Also the drawing tools and treatment of drawing functions give the application of a higher packing in the creation of works of any kind.

On the other hand, the design of the graphical interface of Join the Boards has been carefully designed so that it was common among the different families of devices from Apple. In this way, it facilitates the learning of the application.

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KEY TERMS AND DEFINITIONS

Application (APP): It is the same thing as a software program. While an app may refer to a program for any hardware platform, it is most often used to describe programs for mobile devices, such as smartphones and tablets.

Computer Supported Collaborative Learning (CSCL): It is a strategy of teaching and learning that builds knowledge through a collaborative work supported by technological resources.

Graphical User Interface GUI: It is an interface that is used to issue commands to a computer by means of a device such as a mouse that manipulates and activates onscreen images.

Information and Communication Technologies (ICT): It refers to technologies that provide access to information through telecommunications.

iPad/iPhone: Are mobile devices developed by Apple.

Local Area Network (LAN): It is a computer network limited to a small area such as an office building, university, or even a residential home.

Twitter: Is an online service that allows you to share updates with other users.

Wi-Fi: Is a wireless networking technology that allows computers and other devices to communicate over a wireless signal.

Chapter 3
Personal Learning Environments:
Research Environments and Lifelong Informal Learning

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ABSTRACT

Over the past 10 years there has been a great evolution of technology and the way the teaching and learning process is developed, as well as how research and publication are carried out. The Web 2.0, a term coined by O'Reilly in 2004, has introduced a new concept to the use of the Internet, in particular as it relates to the educational framework. The web 2.0 tools allow the creation of emerging ubiquitous environments that enable the development and management of a real Personal Learning Environment (PLE). This chapter is a proposal for the "Handbook of Applied Research on E-Learning in Engineering and Architecture Education" and represents a literature review on the topic of Personal Learning Environments (PLE). It explores the definition around the concept of PLE, its history, the advantages for its use in a lifelong learning process and its importance in the scope of the present research.

INTRODUCTION

This chapter is a literature review on the topic of Personal Learning Environments (PLE), where we will explore the definition of PLE, its history, advantages for its use in a lifelong learning process and its importance to the field of research in this area of knowledge.

This chapter of the "Handbook of Applied Research on E-Learning in Engineering and Architecture Education" demonstrates the technological advancement relating to the educational framework and the prospect of modernised countries and education based on Information and Communication Technologies.

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The technological advances in the field of education as well as the interaction among students, teachers and researchers with different types of devices have been increasing and changing the shape and way of interacting with digital content, particularly with regard to educational content. Thus, the perception and understanding of a PLE is fundamental for teachers / researchers / students / professionals to promote a greater motivation, satisfaction and academic and professional development, as it enables the use of different technologies and strategies for lifelong learning and a better ubiquitous learning.

Over the past ten years there has been a great evolution in technology, in the way the teaching and learning process is developed, and also in how research and publication are carried out. The Web 2.0, a term coined by O'Reilly in 2004, has introduced a new concept to the use of the Internet, in particular as it relates to the educational framework. The web 2.0 tools allow the creation of emerging ubiquitous environments that enable the development and management of a real Personal Learning Environment (PLE).

With the limitation of Learning Management Systems (LMS), the PLE has emerged in recent years in research papers and publications, recognising the importance of informal learning through social software (Academia.eu, ResearchGate, Twitter, Linkedin, Perltrees, etc) and the importance of getting involved in lifelong learning (Adell & Castañeda, 2010; Castañeda & Adell, 2013b; Mota, 2009).

The concept of Personal Learning Environment (PLE) first appears in 2001, in a text by Olivier & Liber (2001) named Lifelong learning: the need for portable personal learning environments and supporting interoperability standards, where the authors integrate the institutional learning context with a peer-to-peer model that should focus on a personal and lifelong learning (Mota, 2009).

According to Mota (2009; 2011; 2012), the PLE seeks to operationalise the principles of eLearning 2.0, the learner's power and autonomy, "openness, collaboration and sharing, permanent and lifelong learning, the importance and value of informal learning, the potential of social software, the network as a space for socialization, knowledge and learning " (Mota, 2009a:127).

In conclusion, this chapter intends to clarify the concept of PLE, how to build it and the benefits in its use as an opportunity for lifelong learning. This is a current need, to achieve an academic improvement and motivation for a new learning process, with new technologies and using different learning strategies.

DEFINITION OF PLE

In a first analysis, we can say that there is no agreed definition, in the specialised literature, on the term Personal Learning Environment (PLE) because it is still a relatively recent term. There are, thus, two clear aspects on its definition. In a first perspective, the PLE arises as an approach based on applications or web tools (Downes, 2006, 2007), which is not and cannot be considered as a software, but as an environment where individuals, communities and resources interact flexibly (Wilson, 2008) through a set of tools or applications available on the Web 2.0, whether social software (social networks) or not. The second perspective considers the PLE can be represented with technology, including applications and services (Attwell & Costa, 2008), combined, however, with the interpersonal relationship with a network of contacts, an essential part of these environments.

The concept of Personal Learning Environment (PLE) was first mentioned in 2001, in a text by Olivier & Liber (2001) entitled *Lifelong learning: the need for portable personal learning environments and supporting interoperability standards*, where the authors integrate the institutional learning context with a peer-to-peer model that should focus on a personal and lifelong learning (Mota, 2009). That same year, the JISC (Joint Information Systems Committee) funded the NIMLE

(Northern Ireland Integrated Managed Learning Environment) project, which consisted in developing a learning environment focused on students, which could collect and centralise the resources from different institutions. In 2004, the concept was the subject of a session at the annual meeting of the JISC, which focused on student-centred online environments, named Personal Learning Environment (Castañeda & Adell, 2013a). It is noteworthy that the first conference on the subject of PLE appears in 2010 in Barcelona, with the intention of creating a space for researchers and practitioners to exchange ideas, experiences and research around the development and implementation of a PLE, including the design of environments, sociological and educational issues and their effectiveness and desirability as informal learning spaces. The following editions were held in Southampton in 2011, Aveiro and Melbourne in 2012, Berlin and Melbourne in 2013, Estonia in 2014, with registration in monographic issues in Digital Review (2010 and 2011), Edmetic (volume 2, number 1, 2013) and eLearning Papers (volume 34, 2013). In this sequence, the book " Entornos Personales Aprendizaje: claves para el ecosistema educativo en red", by Castañeda & Adell (2013b) was also edited and it is composed of a set of several chapters written by a group of researchers in the PLE field.

Since this is a recent concept, as previously mentioned, its definition is still not consensual in the research community; so there is a need for a literature review of empirical research on this topic, to contribute to the theoretical level and mainly, to the conceptual level, in order to increasingly clarify both the concept and practice of learning it relates to. According to Gallego & Chaves (2014) there are only a few studies on PLE, with the majority of texts / papers submitted to The PLE Conference, but the theses on the subject are still very few.

According to the first full review of the PLE concept performed by Mota (2009b), there are several definitions put forward by several authors, and we highlight the perspective by Lubensky (2006) in which the PLE is defined as being centred on how easy it becomes for the individual to perform actions such as access and aggregation of digital artefacts used and / or explored in the learning experiences he is involved in. According to Siemens (2007), it is a collection of tools combined through the notion of openness, interoperability and student monitoring. Mota (2009b) highlights the vision of Anderson (2007) on the PLE concept, which values the user's knowledge, connecting his personal environment with the educational institutions environments.

In this diversity of definitions that are developed around the PLE concept, there are common elements among them and we may consider that there is a certain unanimity when it is stated that the PLE is an environment controlled by the individual, based on diverse digital resources associated with a given space, requiring identification of the individual (i.e., it will be necessary to access certain resources for an individual / personal record) promoting lifelong learning. In turn, the individual learner has the possibility to increase or decrease the number of resources at their disposal for learning; and finally, another common element, is that it allows interaction with their network of contacts (Johnson, 2008).

In the perspective of Castañeda & Adell (2013a), in the early years the discussion around the PLE issue was characterised by the coexistence of two currents of thought and research: the first, still the legacy of the NIMLE project ideas, sets the PLE as a technological artefact whose goal is to create and generalise the best tool for the PLE. This view is shared by various researchers, among them Wilson (2008; 2006), Van Harmelen, (2006; 2008); Taraghi et al. (2009); Vavuola y Sharples (2009); Casquero et al. (2010); in the second perspective, the PLE is considered as a pedagogical concept defining how learning takes place through access to technology (Adell

& Castañeda, 2010; Attwell & Deitmer, 2012; Attwell, 2007; Couros, 2010; Downes, 2010; J. Mota, 2009b, among others).

According to several theoretical studies, the PLE allows the individual to continually update their knowledge, in a perspective of lifelong learning (M.-J. Gallego & Chaves, 2014), while being a requirement and a necessity in a world that is networked and where technology is used in everyday life. Thus, the individual uses a set of communication and interaction tools for various tasks, activities and situations according to their needs and become learning actors, whether in a formal or informal context. In this perspective, since the origins of the PLE concept there is a relationship between the idea of lifelong learning and the concept of PLE (Torres & Costa, 2013; Torres, Edirisingha, & Mobbs, 2008).

In fact, regardless of geographic space (Garcia et al., 2012), the use of Web 2.0 tools allow the development of a lifelong professional and / or academic learning experience (Attwell & Deitmer, 2012). The individual is, thus, the actor of their learning when they make use of their PLE. There is an increasing number of educational experiences in which the individual uses the technology tools to maximise and enrich their learning through different types of connections (Castañeda & Sánchez, 2009).

Most authors who have dedicated to studying this question (Adell & Castañeda, 2010, 2013; Attwell & Costa, 2008; Attwell, 2007; Castañeda & Adell, 2013a; Linda Castañeda & Sánchez, 2009; Costa, 2010; Dabbagh & Kitsantas, 2012; Fiedler & Väljataga, 2011; Van Harmelen, 2006; Torres & Costa, 2013; Mödritscher, 2010; Mota, 2009a; Väljataga & Fiedler, 2009; Van Harmelen, 2008; Wild, Mödritscher & Sigurdarson, 2008) state that the individual has a decisive and fundamental role in organising, updating and in the way how they build their learning, with greater autonomy and control over what they learn and how they learn. By networking with experts or individuals with common interests, needs, circumstances, activities and tastes, a true PLE is promoted, and the individual becomes a learner who is more capable of autonomous, conscious and responsible decisions about their paths and their learning.

The PLE is a reality with great potential, connecting two distinct worlds (personal and academic) and interrelating lifelong learning with learning held in educational institutions (Attwell, 2007). We may refer to the PLE functions of a web interface allowing content management, formal and informal, in a collaborative and individual work, where the profiles are interconnected in a particular time and place, but this location and timing are of no importance, since the PLE assumes characteristics of ubiquity that make learning an activity without time or space, i.e., beyond physical time and space as they were conceived until a few years ago.

The PLE is an environment where the individual connects to other environments that involve a social universe that allows sharing collaborative knowledge through filtering and selection criteria and information management (Attwell, 2007; Torres et al., 2008). Empirical studies by several authors focus on this idea, namely Attwell & Deitmer (2012), Casquero, Ovelar, Romo, Benito, & Alberdi (2013); Chatti, Dakova, Thus, & Schroeder (2013); Garcia et al. (2012); Gea, Montes, Gamiz, Raposo, & Arjona (2012); Grosseck & Holotescu (2010); Halimi, Seridi-Bouchelaghem, & Faron-Zucker (2014); Harris, Earl, Beale, Phethean, & Brughmans (2012); Ivanova, Grosseck, & Holotescu (2012); Marín, Salinas & Benito (2014); Panckhurst & Marsh (2011); Rahimi, Berg, & Veen (2013); Reisas (2012) and Tomberg, Laanpere, Ley, & Normak (2013).

In their study, Panckhurst & Marsh (2011) were able to conclude that social networks allow greater autonomy and more responsibility in the individual learning process, fostering greater motivation for this process and an increased sense of freedom, compared with limitations presented by the academic VLE (Virtual Learning Environ-

ments) and LMS (Learning Management System). Anderson (2006) identified six advantages of the PLE in the learning process: a) identity - learners have existence beyond formal school; b) ease of use - customisation by the user; c) control and responsibility of ownership - content belongs to the user; d) copyright and reuse - the owner and not the institution has to make these decisions; e) social presence - support of communication and online culture; and f) capacity of speed and innovation - new applications evolve rapidly and new features invade the PLE conglomerate in the learning setting.

In the perspective of Attwell (2007), Torres Kompen et al. (2008) and Olaniran (2009), the PLE appears as a flexible alternative for individuals to adapt content, tools and sources to their personal circumstances, creating the opportunity to choose according to their knowledge and according to their needs, preferences, culture, pace, and last but not least, according to their learning style.

Palmér et al. (2009) and Ramírez et al. (2013) provide comparative analysis of various platforms that can be used to build a PLE, in particular platforms that promote collaborative actions, as well as a balanced customisation. These theories support the idea that the PLE allows the individual to have greater choice in their customisation, adaptation and interaction with the tools in a more natural and spontaneous way, since they may be chosen by themselves to promote a better learning, as can be seen in several empirical studies (Aresta, Pedro, Santos, & Moreira, 2012; Attwell & Deitmer, 2012; Buchem, 2012; Chatterjee & Mirza, 2012; Dahrendorf, Dikke, & Faltin, 2012; M. J. Gallego & Gámiz, 2012; Gea et al., 2012; Ivanova & Chatti, 2011; Ivanova et al., 2012; Jarvis, Gauntlett, & Collins, 2010; Leone, 2013; Paz, 2012; Rahimi et al., 2013; Tur & Urbina, 2012). In their study in nine Spanish universities, Casquero et al. (2013) found that students who used a variety of web 2.0 tools and social networks to build their PLE could more easily complete the activities that were proposed. Students being connected through the internet could create greater fluidity in participation and collaboration among themselves, by sharing.

Gallego & Chaves (2014) argue that it is remarkable that empirical research on PLE has found arguments that justify the psycho-didactic point of view, stressing its importance and the fact that they provide a true digital identity.

In short, we may consider a PLE as a personal space mediated by technological applications that enable learning through interaction with other individuals with whom they are connected in the same space of the Web 2.0. These environments are dynamic and continuously documenting formal and informal learning, where there is multifaceted information related to similar contexts, organised by technologies that enable learning through communication, thinking and reflection. Thus, it allows a free, autonomous and individual-controlled learning, in terms of the online spaces where they are registered and interacting and sharing with their network.

PLE in Empirical Research

Being a recent term in the context of learning technologies, it is normal that we find a diversity of meanings as subject of empirical study, with varying degrees of depth, features and emphases, which makes it more difficult to find a specific definition of PLE that is consensual for the majority of researchers who are interested in this area.

The PLE goes far beyond technology and requires changes in personal and collective educational practices, being unanimous the fact that it is a user-centred online learning environment that enables lifelong learning. According to the perspective of Martindale & Dowdy (2010) and Castañeda & Adell (2013b), in the early discussion of the problem of PLE was characterized by the coexistence of two currents of thought and research. The first perspective considers the PLE to be conceived as a set of elected, integrated and used by an individual technology tools to access

new sources of knowledge (Chatti, Agustiawan, Jarke, & Specht, 2010; Chatti, Jarke, Wang, & Specht, 2009; Johnson & Liber, 2008; Gallego & Martínez, 2013; Ros et al., 2013; Saadatmand & Kumpulainen, 2013; Scheffel, Wolpers, Schmidt, & Werkle, 2013; Tu, Sujo-Montes, Yen, Chan, & Blocher, 2012; Van Harmelen, 2006; Wild et al., 2008b). The PLE may be a set of devices, tools, applications, and physical or virtual spaces associated by individuals at a given time, to make their reading and editing on the web, either through an LMS or other formal learning spaces (Gillet, Law, & Chatterjee, 2010). Thus, the LMS and the VLE arise as tools complementary to the particular PLE of a particular student, as noted by Torres et al. (2008).

A related factor for greater enthusiasm for PLEs is a critique of VLEs as institutionally-owned and driven, and as serving the needs of the institution rather than the learner (EDUCAUSE, 2006). Learners have limited control over the extent to which the tools of a VLE can be customised. Developments in Web 2.0 technologies offer opportunities to make use of tools and services that are free and available in the public domain, with potential for integrating formal and informal learning (McFedries, 2007). (Torres et al., 2008, p. 2)

White, Davis, Morris, & Hancock (2010) conducted a study that concluded that students confirmed the ubiquity of the Internet, most often choosing Google tools and Wikipedia, as well as elements of the Web 2.0 as facilitators of learning, thus creating a link between their personal spaces through the Web 2.0 applications and the academic environment (VLE and LMS).

In this line of work we also find studies by Llorente Cejudo (2013), Nikolaou & Tsolakidis (2013) and White et al. (2010) that characterize the technological tools that comprise the PLE as accessible, of considerable usability, connectivity, security, adaptability, among other features, providing a solid and meaningful lifelong learning.

Thus, the PLE appears as a cluster of Web 2.0 tools or applications that can be used in the learning process, without any limits, provided that they allow the individual to enrich their knowledge and / or provide them a learning process in which there is novelty.

Attwell (2007) states that the PLE is composed of tools that the individual uses in their daily life allowing them to be autonomous, managing their own time dedicated to learning through the use of the internet.

It goes on to consider some of the pressures for change in the present education systems. The idea of a Personal Learning Environment recognises that learning is ongoing and seeks to provide tools to support that learning. It also recognises the role of the individual in organising his or her own learning. Moreover, the pressures for a PLE are based on the idea that learning will take place in different contexts and situations and will not be provided by a single learning provider. Linked to this is an increasing recognition of the importance of informal learning. (Attwell, 2007, p. 1)

In the same line, and reinforcing what has already been addressed, Ricoy & Couto (2010) also argue that this selection and dynamics of personal and intellectual development takes its name from PLE. Each user may be autonomous, manage their own time and dedication to their learning through the Internet. These learning environments exist due to the development of web 2.0 technologies, based on social interaction, sharing and collaboration.

This first line is reflected in the theoretical proposal by Adell & Castañeda (2010) as a conceptual approach to the PLE and ratified later by the same authors in 2013, where the PLE is a group of tools, information sources, connections

and activities that each person regularly uses to learn, composed by mechanisms that allow information to be recreated and rebuilt as knowledge (Adell & Castañeda, 2013).

Adell & Castañeda (2010) state that they are aware that the PLE goes far beyond technology and it involves spaces and strategies of face-to-face world that the individual uses to learn. The social web appears as an environment that brings together the sources, activities and connections made by many individuals with total connection to their lives at personal, professional and academic levels.

The PLE considered as a concept corresponds to the second line of thought, where the PLE is regarded as a theoretical and abstract pedagogical construct, where knowledge and learning can be acquired and consolidated through Web 2.0 tools and in particular through the social web. In this line of thought we may find theoretical works by authors such as Castañeda & Adell (2011), Downes (2010), Drexler (2009) and Wilson (2008).

Downes (2005) goes on to describe the PLE as a node in a content network, connected to other nodes and content creation services used by other network users. Thus, the PLE becomes not a corporate or institutional application but a personal learning centre, where the content is reused and re-edited according to the needs and interests of the user, forming a collection of interoperable applications in an environment instead of a system. In this perspective, learning follows practice, dialogue and interaction with others in networks that are themselves, connected, interactive and open channels, allowing each student to build their learning space, focusing on their needs and interests.

The PLE operates at a personal level in that it coordinates services and information that is related directly to its user and owner. However, the PLE can also be considered global in scope, as the range of services it can potentially coordinate is not bounded within any particular organization. The user can connect their PLE with social networks, knowledge bases, work contexts, and learning contexts of any size to which they can obtain access. (Wilson et al., 2006, p. 33)

For Wilson et al. (2006), the Personal Learning Environment promotes the practices of users in relation to learning using various technologies, thus overcoming the design problems inherent to modular systems of VLEs (Virtual Learning Environments). In the view of the authors, the PLE creates bridges between formal and informal learning, fulfilling the goal of lifelong learning, integrating the experiences in various contexts, with the emerging environments of social software and the new paradigm of the Web 2.0.

This idea is also presented by Skrabut:

Personal learning environments (PLE) are being created as a means for individuals to control their own learning. While higher education has been the predominate force in formal learning, it seems that more and more individuals are using PLES, PLEs are a more natural way to learn. PLEs incorporate the strengths of constructivism and connectivism learning theories as well as those of self-directed learning. Very simply, learners want to interact with others and have choices in their learning. (Skrabut, n.d., p. 3)

Attwell & Costa (2008) refer to the PLE as a new approach for developing e-learning tools, based on the ideas of collaborative learning and social networks within communities of practice. Thus, in the perspective of these authors, PLEs are constituted by a set of tools used for work, learning, reflection and collaboration with others through sharing, being seen as a space for interaction, communication between individuals, whose end result will be learning and developing experience and collective know-how. In this sense, the most important in these environments is the idea of: a) supporting individual and group learning in multiple contexts; and b) promote autonomy and learning control by the user.

With the evolution of social software and the conceptual discussion around PLEs, changes are more visible, that intend to reflect on emerging pedagogies as a result of emerging digital environments and technologies (Oliveira & Morgado, 2014). For example, reflecting on this, Schaffert & Hilzensauer (2008) have identified seven aspects where there are changes in learning accomplished with the support of the PLE:

- The role of the users as active content creators chosen by themselves and for themselves;
- The customization with support and data from community members;
- The learning content as unlimited space;
- The role of social participation;
- The ownership of learners' data;
- The meaning of self-organised learning for the culture of schools and organisations, and;
- The technological aspects of the use of social software and aggregation of multiple sources tools.

In the perspective of Mota (2009a), the PLE seeks to operationalise the principles of eLearning 2.0, giving power and autonomy to the learner through "openness, collaboration and sharing, continuous and lifelong learning, the importance and value of informal learning, the potential of social software, the network as a space of socialisation, knowledge and learning" (Mota, 2009a, p. 127).

Building a PLE

A PLE configures itself around the tools and services that allow access and contact to and with information and the relationship with other people with common interests or concerns, with users creating their settings for these social Web 2.0 tools. Thus, according to Attwell (2007), the tools used in the PLE enable reading, reflection and sharing. By supporting the individual in the learning process anytime, anywhere, the PLE should allow and offer support and functionality in mobile communication devices, such as smartphones, iphones, ipads or tablets (Cataldi & Lage, 2013). Each PLE has its own identity, which is the personal choice of each individual in terms of resources / tools available, depending on their learning goals.

A PLE is comprised of all the different tools we use in our everyday life for learning. Many of these tools will be based on social software. Social software is used here in the meaning of software that lets people rendezvous, connect or collaborate by use of a computer network. It supports networks of people, content and services that are more adaptable and responsive to changing needs and goals. Social Software adapts to its environment, instead of requiring its environment to adapt to software. Social software underpins what is loosely referred to as Web 2.0… (the web 2.0) is a two way process, allowing the internet to be used for creating and sharing information and knowledge, rather than merely accessing external artefacts. (Attwell, 2007, p. 4)

According to Bernal Galindo (2010) the Web 2.0 tools available for the learning process are divided into three categories:

1. **Communication:** In this category we may find all the tools that allow transmitting a collaborative and interactive information, synchronously or asynchronously, with tools as social networks, chat tools, videoconferencing, podcasts, among many others.
2. **Creating and Publishing Content:** This category comprises all Web 2.0 tools that enable the creation of content as text, image and video. Some of these tools also allow for synchronous and asynchronous interaction. Some of the tools available to

work within this framework are: video - YouTube remixer[1]; photography - Picasa[2]; documents - Google Drive[3], One Drive[4]; Mindmaps - Mindomo[5], Mindmeister[6], Gliffy[7]; Publication - Slideshare[8], Scribd[9], Issuu[10], and finally presentations – Prezi[11].

3. **Information Management:** Social bookmarks are a great tool for managing information, they help store and categorise all the information found regarding a specific topic. Another feature is the ability to share resources stored in different groups according to common interests through curation websites or social media. The following tools stand out in this category: Dropbox[12], SugarSync[13], Diigo[14], Delicious[15], Scoop.it[16], Mendeley[17], Zotero[18], among others.

Adell & Castañeda (2010) mention three types of elements that a PLE should have:

1. **Reading Strategies and Tools:** The sources of information the individual has access to, that provide them with information (blogs, wikis, repositories, youtube, vimeo, slideshare, online libraries, RSS readers, online magazines, among others);
2. **Reflection Tools and Strategies:** This aspect refers to environments or applications that allow the transformation of information (spaces where it is written, comments and analyses), such as wikis, online office with editing tools (Googledrive, Zoho, mindmaps, Conzilla, among others); and finally,
3. **Networking Tools and Strategies:** Environments where the individual relates to other people with whom they have a relationship of sharing, especially in the social networks where the individual is present. This last element in which you learn from networking with others through social networks is a crucial element in the PLE, known as Personal Learning Network (PLN) (Morrison, 2013; Oliveira & Morgado, 2014; Richardson, 2013; Siemens, 2011; Tobin, 1998).

Utecht (2008) provides useful advice on the stages of a Personal Learning Network:

1. **Immersion:** Find opportunities to connect and create networks where you can meet people and know ideas to connect or that represent added value to our knowledge in order to create a collaborative network;
2. **Evaluation:** Examining networks and removing the ones that become unnecessary;
3. **Know Everything:** The ability to understand what is necessary to learn and choose what to do to learn, leveraging the power of their network, not to waste time;
4. **Perspective:** To give importance to other activities that are being overlooked or neglected; and finally,
5. **Balance:** Finding the balance between learning and life.

This chapter does not intend to exhaustively explore the concept of PLN, but it is important to mention this term as connected to the PLE in the social dimension, because the behaviour of the network and its sharing has an influence on the acquired knowledge. The potential of the PLN depends on the relationships that are developed in the network according to the various learning interests (Oliveira & Morgado, 2014). Three types of networks may be defined, according to their needs (Castañeda & Gutiérrez, 2010):

1. When we connect with information objects such as youtube, Flickr, Slideshare, Scribd, among others, where the interest lies in learning through the networks and the posts published by users, whether they are text files, video, photography, presentations or a combination of some of these files.

2. The relationships that are based on communication of what is done and learned outside the environment and the focus is on sharing places with interest, through experience and resources to learn, such as Delicious, Diigo, Mendeley, Scoop.it, among others.
3. The networks that serve to establish relationships with other people and where learning is accomplished by the interaction among users, as is the case of social networks: Facebook, Linkedin, Twitter, Ning, and others.

Sometimes it is hard to realise the places where we are and what tool or application we must provide for access to knowledge. To assist and facilitate access to the places where you are or where there is an interaction, there is a very useful tool, that allows you to gather, in a single space, all the locations where there is interaction by the user - this tool is Symbaloo[19]. Symbaloo is an aggregator of different tools or applications where the individual is present and that are part of their PLE, allowing the individual to have a sense of the spaces where they are registered and where they share knowledge with their network, thus building upon their digital identity.

Thus, the PLE is not only composed of a technological environment, but also digital identity and relationships, and online or in-person interactions with other individuals. In the online social dimension there are two ways to achieve or be predisposed to learning: the one that arises from a two-way sharing in which an individual is directly related to the other individuals they are connected with, as is the case of social networks (Facebook, Linkedin, twitter) or via e-mail or through another element, which is predominantly unidirectional and the user acquires knowledge through what is shared by others, without any interaction with the author of the resource made available, as is the case with personal websites, blogs, wikis, curation sites (paper.li; scoop.it, among others), or scientific papers / texts.

The PLE is an individual environment and a universal model is not possible because each individual has their personal needs and concerns. The PLE is the result of individual choices and their chosen activities, their options in each moment, as well as tastes, circumstances and needs. In fact, in this sense, each individual makes their selection of tools that are of interest for them and follow the shares that make more sense for themselves and their learning. This allows the individual to set their own learning goals, manage their learning in terms of content and processes and ultimately interact with others in their learning process to achieve their learning goals (Cataldi & Lage, 2013). Building a PLE involves searching, selecting, deciding, valuing, i.e., building and rebuilding their own network of resources, information flows, experts or people with common interests (Adell, 2013).

A PLE should allow learning about a particular topic of interest that is chosen by the individual, where this learning is done at their own pace and suiting their needs. This process allows each person to give it the depth and importance it has for themselves, but it is a process that allows lifelong learning, enabling the acquisition of new skills where the individual is both producer and consumer of knowledge that is simultaneously free and open.

Adell (2013) makes a reference to the first steps in creating a productive PLE for the individual's learning process:

- Create an account on social networks and follow the experts in the fields of interest or where there is greater need for learning and ideas should be shared and experts contacted;
- Regularly monitor what is published on the topic of interest via RSS;
- Use bookmarks in order to share ideas and knowledge acquired through others;
- To start, it is important to slowly create a digital identity through the interests and

needs, but it is important to stress that one should use the same username in all online spaces in order to give credibility to the presence in the online space;
- Test tools that are desired to form an integral part of the PLE, verifying that they meet the requirements for which they are required;
- Be observant and thoughtful of standards recognised by the digital community in the interactions with others, respecting the rules of network use.

The vast number of tools, supporting collaboration on the web is an indicator that PLE and social software tools are not only a flash in the pan, but lead to a new notion of learning and a measure for sustainable competence development. (Schaffert & Hilzensauer, 2008, p. 1)

So, what dictates the characteristics of a particular PLE are the needs of the person who builds it and not issues related to any feature of the technology. To obtain a true PLE it is necessary that it is, on one hand, personal and, on the other hand, that there is demand, selection, decision, value, and also that the individual needs to continuously build and rebuild their own network of resources, tools and followers. This implies connecting and communicating with people who share the same interests or who are experts in a specific area related to their own interests. Building a network is an ongoing process, because every day there are new tools with bigger potential, and the individual meets new people in the same area of expertise and with common interests. The individual produces an active, critical and selective learning, being able to choose what to learn and how to learn, interacting with the learning content. Technology is the tool or means that allows the selection and combination of different media for the individual's learning, who is, at the same time sender and receiver of knowledge. Their learning is individual, but it is never done in isolation, because the author is always connected to their network of contacts that should keep dynamic and constantly expanding.

In short, as stated by Attwell (2007): "Personal Learning environments are not an application but rather a new approach to the use of new technologies for learning. There remain many issues to be resolved. But, at the end of the day, the argument for the use of Personal Learning environments is not technical but rather is philosophical, ethical and pedagogic" (Attwell, 2007, p. 7).

The Relevance of the PLE

Why the development and the relevance of the PLE?

This is a pertinent question to realise the importance of this topic nowadays, in the twenty-first century, for the individual who intends and requires constant and lifelong updating.

In the last decade, the PLE has had a great importance in the learning process and has been considered as a means for lifelong learning, as well as an aid to formal learning, also considered as an asset in relation to informal learning. In this sense, the tools that compose the PLE are digital, not digital and internal (learning plans and strategies) resources that the individual uses to achieve their goal, thus taking advantage of certain learning outcomes, generally with high levels of satisfaction to the individual.

To Schaffert & Hilzensauer (2008), the PLE has changed the paradigm of the teaching-learning process, creating new challenges. The authors identified seven aspects where changes are more obvious:

Learning with PLE leads to changes concerning: (1) the role of the learner as active, self-directed creators of content; (2) personalisation with the support and data of community members; (3) learning content as an infinite "bazaar"; (4) the big role of social involvement; (5) the ownership of learner's data; (6) the meaning of self-organised

learning for the culture of educational institutions and organisations, and (7) technological aspects of using social software tools and aggregation of multiple sources. (Schaffert & Hilzensauer, 2008, p. 1)

Harmelen (2006) considers that a PLE provides an interface to obtain information from various institutions and web spaces, placing the domain of the learning process according to the individual needs, both online or offline. Thus, the user has more control over the resources that are part of their PLE, as well as control of the connections they use to build their own personal network of contacts.

The main actors of the PLE research are the individual on the one hand, and technological tools on the other, together with the relationships that are established between both, as argued by the authors that have been studying the topic: Marín et al. (2014), Kop & Fournier (2013), Cataldi & Lage (2013), Sousa et al. (2011), Mödritscher et al. (2010), Aresta et al. (2012), Rahimi et al. (2012), Ivanova et al. (2012), Harris et al. (2012), García et al. (2012), Gallego & Gámiz (2012), Dahrendorf et al. (2012), Chatterjee & Mirza (2012), Panckhurst & Marsh (2011), White et al. (2010), Torres et al. (2010), Llorente (2013), Castañeda & Soto (2010), Santos et al. (2013), Friedrich et al. (2011), Ruiz-Palmero et al. (2013) y Marín (2013).

The aforementioned studies report or show the three dimensions already mentioned above, in which the emergence of the Web 2.0 and its influence today in the field of Social Sciences has been very important and has led to several studies and progress in order to face the use of technology in that science and even in education.

Most of the texts on PLE consist mostly of texts submitted to conferences (40%). 44% were submitted to The PLE Conference, 34% were published in scientific journals between 2013 and 2014, and the publication of this issue in books and theses is scarce (although lately there have been more research theses, their publication does not exceed 11%) (Gallego & Chaves, 2014). The trend observed indicates that the number of publications tends to increase. With the vast majority in the English language, there is also a large number of texts written in Spanish, with one of the texts / reference books being written by Castañeda & Adell (2013b).

Most of the published research has been characterised primarily by the importance attributed to the pedagogical component, highlighting its importance as an element that allows the individual to create an identity. Gallego & Chaves (2014) point out some key aspects such as: a) permanent, continuous and ubiquitous learning; b) a tailored, appropriate and personalised learning to each individual; c) self-management and self-regulation of the learning process by the learner; and d) the fact that learning implies sharing, collaboration and co-creation. These aspects allow the individual to understand the notion of PLE and its function to acquire knowledge and deepen knowledge. Despite being a recent term, a more outlined sense of the concept is starting to be built, or at least, it is presented in two perspectives, and one does not refute the other, i.e., the tools are an integral part, but they are not the foundation of the PLE concept. Because learning takes place more within the relationship the individual has with the tools and social spaces (social networks) where they are, such aspect allows them to create, stimulate and foster their learning process.

In this sense, it is relevant to refer the advantages that the PLE features for learning lifelong according to Rodrigues (2012):

- **Identity:** Individuals benefit from online tools or applications that go beyond formal training, allowing them to contextualise their own understanding;
- **Perseverance:** The intrinsic reflections that arise in online spaces become digital

files in a learning process, which can be upgraded through lifelong learning, depending on the evolution of such learning;

- **Ease of Use:** The PLE allows for individual customisation that is not limited to a number of platforms;
- **Ownership, Control and Responsibility:** The autonomy of learning is the responsibility of the individual, as well as the platforms and tools that are part of their PLE, that is their own responsibility, that is, the choice of tools is made by the individual, thus becoming their personal PLE;
- **Copyright and Reuse:** Contributions to a PLE are owned by the individual or their network of contacts and they are shared by those who are connected with others (individual and their network of contacts or vice versa);
- **Social Presence:** The domain of social software and integration with social networks by the individual allows them to create a digital identity, in which their contact and interaction with their network are performed depending on personal needs, enabling the individual to improve performance and knowledge;
- **Ability to Innovate:** The increase of Web 2.0 tools promotes greater innovation and creativity in building a PLE, allowing the individual to share and build knowledge;
- **Lifelong Learning:** The PLE is made dynamic by Web 2.0 applications and what each user shares, enabling a personal and lifelong learning.

Talking about the PLE is referring to an educational innovation using new ways of learning through knowledge society and it is also assuming that the individual training in the future will undergo a training in formal and informal contexts, where the Web 2.0 has made the difference in the perspective of social interactions through social networks that have greatly facilitated the construction of new knowledge.

SYMBALOO

As part of the "Handbook of Applied Research on E-Learning in Engineering and Architecture Education" this chapter intends to describe a tool that is possible to adapt to the reality of engineers and architects. This tool is free and available online and it consists of aggregating all online spaces where engineers and architects are present and the tools used in their daily life, in terms of their personal, academic and professional functions. This aggregator is named Symbaloo, and its name has a Greek origin, with the meaning of gathering.

Figure 1 shows the aggregator and it is possible to visualise the possibility users have to aggregate pages according to their study or work field, where each section might then refer to specific cases they are working at, i.e., it allows users to create a window for each interest or use.

Figure 2 shows an example of how an architect uses Symbaloo with professional and academic purposes. Each block represents a hyperlink to a web space or contact network. With these connections, the user may have a dynamic and updated PLE, because Symbaloo has an extension that may be adapted to each user. When using the web, there is a great need to organise and understand the several spaces one is registered at. Another advantage is the possibility to group the hyperlinks in colours, defining interests, which allows an easier access to the intended information.

In conclusion, this tool allows individuals to create a working area, enabling a faster access to the favourite pages, not only the most used ones, but also some of the least visited, that are organised in topics and are able to be explored in a visual way. Actually, it is possible to create themed ar-

Figure 1. Symbaloo

Figure 2. Example de PLE de Enric Gabarró (Architect)[20]

eas, with all the most important and used pages. In the centre, there is a multifunctional box that can be used to show the most important information or useful tools, such as calculator, calendar, Google search or the weather. It is a very useful tool for architects and engineers to group all the web spaces they use, allowing them to organise them according to their personal, professional and academic areas.

CONCLUSION

This chapter has sought to clarify the concept of PLE, how to build these customised learning environments and the benefits of their use, as an opportunity for a constant lifelong learning. This is an imperative need nowadays, connected to academic improvement and motivation to acquire new knowledge, by using and combining different technologies and learning strategies to enhance factual, conceptual and procedural knowledge, as now required at all levels, both in the personal as well as professional and academic dimensions, in a constant, interactive and iterative lifelong process.

Indeed, there is the view that "moreover, PLEs can provide more holistic learning environments, bringing together sources and contexts for learning hitherto separate. Students learn how to take responsibility or their own learning. Critically, PLEs can bridge the walled gardens of the educational institutions with the worlds outside. In so doing learners can develop the judgements and skills or literacy necessary for using new technologies in a rapidly changing society." (Attwell, 2007, p. 7). In Personal Learning Environments, individuals develop their independence and critical spirit, becoming the main actors in their approach to training, holding now the ability to decide, as well as the awareness and responsibility regarding the paths chosen to build their knowledge.

In conclusion, with tools such as Symbaloo, architects and engineers have the possibility to develop an excellent PLE, grouping in one single space all the online tools and spaces they regularly use, and also to include the academic area or any other field they are interested in or have knowledge about.

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KEY TERMS AND DEFINITIONS

Digital Identity: The identity that creates each individual to register on web 2.0 applications where it is present, sharing, reflecting and binds to other members of your network of contacts.

Digital Literacy: The knowledge, skills and behaviors that users have with computing and digital devices.

Informal Learning: Consists in learning what each individual does with their peers or society spontaneously or intentionally.

Learning Lifelong: It's an ongoing, voluntary and self-motivated in seeking knowledge to technological, professional and personal level, which promotes social inclusion, active citizenship and personal development action.

Personal Learning Environment: An environment that allows the individual to take control of managing your learning process, facilitating his learning lifelong.

Personal Learning Network: The network created for learning and sharing knowledge with the experts in the areas of personal interest.

Social Software: Consists of all applications that exist on the internet the concept of web 2.0.

Web 2.0: A term created by O'Reilly in 2004, which represents the evolution and interaction of individuals with the internet these days.

ENDNOTES

1 https://www.youtube.com/editor
2 http://picasa.google.com/
3 https://www.google.com/drive/
4 https://onedrive.live.com
5 http://www.mindomo.com/
6 http://www.mindmeister.com
7 http://www.gliffy.com
8 http://www.slideshare.net/
9 https://scribd.com/
10 http://issuu.com/
11 http://prezi.com/
12 https://www.dropbox.com
13 https://www.sugarsync.com
14 https://www.diigo.com
15 https://delicious.com
16 www.scoop.it/
17 www.mendeley.com
18 https://www.zotero.org
19 http://www.symbaloo.com
20 Cf. http://www.symbaloo.com/mix/pleenricgabarro

Chapter 4
Hybridization-Based Courses Consolidated through LMS and PLE Leading to a New Co-Creation of Learning: Changing All Actors' Behavior for Efficiency

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ABSTRACT

Over the last two decades the evolution of IT has sped up in such a way that teaching practices and learning methods have evolved. On the first hand, the motivation relies on a quick access to data for learners attending a course or during sandwich courses. On the second hand, a greater access to contents leads to a new relation between trainees and trainers (a new attitude enforced by specific pedagogy for Continuous Vocational Training). Despite some drawbacks and the generated new behaviors of the digital generation, the internet connection speed, the new devices and tools (LMS) undoubtedly stress the integration of ICT in the training model. The challenge for accessibility, good education and collective work benefits the development of innovative solutions; enforced by the Higher Education framework in Europe. But even if funds are directed for techniques, only a few efforts are given to help a new posture for trainers.

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INTRODUCTION

At the University, training is performed but also designed and managed by the skilled workforce composed by professors and Senior Lecturers (teacher-researchers); whom we refer to as trainers in the following. They teach, do tutoring and guide trainees, develop research work in specific fields but also have other responsibilities in the organization. They do management and, therefore, are the ones stressing and supporting the creation of new pedagogical tools to improve the skills of trainees; due to this specificity, they are the ones who develop and use such innovative pedagogical devices in the complex environment of Higher Education (HE); putting into practice what we call hybridization-based courses combining blended learning with other means. In the following, first the background of HE is introduced. Secondly, a focus is put on the impact of current evolutions (context, public, ICT, society…) on the stakeholders. Thirdly, a survey on training and learning is given to help understanding of the added value of the innovative pedagogical device called *ONAAG (Digital Support for Guided Self-Learning)* which is presented later. It is the result from a strategy-based experience whose core and motivation rely on the hybridization of means in the framework of a flipped classroom; for better knowledge acquisition, ability to learn and higher level of cooperation between actors in a group. A feedback is given on the project management aspect; customer focus (quality, efficiency). The device itself and the use of it by the trainer are presented with the results obtained with two groups (learners and apprentices). Finally, stress is put on the usefulness of the device for a higher involvement of all actors (trainers and trainees) and a better transfer of competences; new paradigm of actors, new use of ICT, identifying levers through a progressive process of learning and virtuous circle of development. In the conclusion, the experience is put into the perspective of the social commitment of the training offer.

CONTEXT FOR HIGHER EDUCATION PROVIDERS

European Background

The Bologna process marked the outset of the construction of the European Higher Education Area set for 2010. During this decade the creation of the European Credit Transfer and Accumulation System (ECTS) by European Community led to a tremendous change in the organization of European HE providers; their challenge was to improve their operations for readability, trade and mutual recognition. The creation of the European Network of Quality Assurance in 2003 and the registration of the agencies that respect the European Standards and Guidelines reveal European pressure to change the perspective of framework for good education with return on investment, respect of accessibility, level of cooperation between stakeholders, ability to improve in all domains that influence performances. The consequence is, on the first hand, the introduction of quality management by HE Providers; a strategy enforced by agencies like the High Council of the Evaluation of Research and Higher Education in France (which links training and research) in consistency with ISO 9001:2008 and soon 9001:2015 (Nuninger & Châtelet, 2015). On the other hand, the development of ICT has started to be consistent with the European Accessibility Act (2011) and the Equality Challenge Unit for HE as a reply to the challenge of the United Nations (art. 24, since 2006). The quick developments of IT tools and the increasing number of new media to access contents are providing new opportunities for trainers based on a new use of time in the classroom and outside the classroom.

Training is a Personal Development Opportunity

Currently, knowledge is widespread due to the tremendous development of ICT (quick access

to a great amount of information through the internet, fully validated or not), but finding the right, correct and worthwhile information seems harder for trainees. As a consequence, the aim of training is now much more to develop learning ability of learners than giving knowledge alone. Trainers are currently facing a multiple choice of possible media whose efficiency mostly depends on the given training goals. The consequence is a strengthened reflection to have upon outcomes (before starting the courses). The way to achieve the expectation has to be thought about, taking into account the public specificity, the available time through ECTS but also the given resources (human, material and technical resources, that is to say funding) and of course the local and international environment. The trainers (mostly professors and teacher-researchers) have to change posture: they are not only depository of knowledge but have a consolidated public assignment; to develop a good education, to improve transfer and to innovate in any performance field to satisfy expectations of society. The ability to transfer is somehow part of the work and especially for those involved in Work Integrated Learning with alternation because of professional competency-based curriculum and immediate impact of results into the workplace (Nuninger & Châtelet, 2014).

Hybridization of Means to Adapt Training

The expectations of trainers have changed through the years (with respect to their career, the given resources for operation). In addition, the generations, the needs and behaviors of trainees have changed too (entirely connected, urging instant satisfaction of their wishes) in a globalized competitive world quickly changing. One may wonder if they have the capacity to aggregate information through a positive criticism of turnkey solution. Through their past experience of learning, are they able to develop their own environment and learning strategy taking advantage of ICT? This requires energy and skills. Learning Management System (LMS) can be part of the solution (teacher centered) as it gives access to centralized dedicated data and Personal Learning Environment (PLE), but both depend on each actors will. Therefore, the trainers will have to use a coordinated set of means and media during result-oriented courses; what we call a hybridization-based course implemented in a cooperative way (support services as IT developers, training engineering, educational engineering and research laboratories dedicated to personal and professional development). It is no more giving theory within examples but guiding the analysis of problems and initiating collaborative discussion to co-create part of cognitive knowledge based on individual real experimental situations; such as practical experience, problem based learning... ICT can now be useful to help the matter as a mean for interaction and permanent link of worthwhile information and feedback. This is consistent with university requirements for coordinated set of devices to meet the needs of the public fully throughout their life course. The pedagogical device should be developed and implemented taking into account the customers' needs; Plan-Do-Check-Act and value management. This is a voluntary initiative (by the teacher) sustained by right policies in HE Providers or education community for better transfer and innovation; consistent with social responsibility.

LOOKING BACKWARDS ON TRAININGS

Evolution of Training

HE Providers have to face an increasing number of students due to social evolution of the standard to enter university. They have the obligation to graduate them in a minimum amount of time and at low cost; the optimization of cost is a necessity. As a consequence lectures in front of huge groups of students are somehow an easy rule, mostly based

on history. Unfortunately it is not so efficient for the success of all. Engineering Schools (in close relation to the industrial world) had already integrated into the courses a mix of lectures, tutorials and practical work; the latter increasing for higher efficiency. In addition, for chartered engineers training periods in the company are required and projects are frequent (in groups or alone). This requirement is now developed for all trainings at the university, integrating project management with case study and industrial subject too; an evolution mostly relying on the will of the pedagogical committee.

Impact of ICT on Trainings and Actors

First computers were introduced at school for the administrative services (finance) but, as they became simpler to use and cheaper, they became ordinary tools of the trainer (writing, calculus) and then, entered the classroom; a convenient tool for practical work requiring reports… Computers facilitate and make gain time, but a tool to which one has to be trained to the use. The creation of the first network of interconnected computers ARPAnet in the late sixties (Abbate, 1999) allows information exchange through the current known World Wide Web (since 1990). In knowledge society, HE Providers started to use the WEB as a way to give and release information for their community or public (Sahlberg, 2010). With respect to courses, the given information is static and limited. Emails and newsgroups allow some ways to discuss contents but access mostly relies on the school due to network connection availability. The tremendous evolution of ICT changed the situation. Computer Supported Collaborative Work were developed for both use in the organization and in project tracking for students. Further, specific solutions appeared such as WIKI, to support collaboration and develop knowledge, Contents Management Systems (CMS) to manage an increasing number of resources and users; creating new community at different levels. Then LMS (like Moodle to support classroom providing new opportunity of exchange and possible feedback) is the main signal of a shift in training and learning behaviors not only limited to information transmission; indeed solutions for follow-up and assessment are proposed. As a consequence, trainees and trainers are changing behaviors while re-building the learning environment in and outside the classroom (Biddix et al., 2014). The development of MOOC (free access and slight assessment) shows the wish of trainees for more autonomy and user-friendly community whereas trainers wonder about quality and more efficient use of the available resources; through flipped classroom for instance. The aim is to strengthen learning thanks to prepared sessions, identifying difficulties, guiding and personal follow-up, going forward. It might lead to higher quality of assessment of personal skills. As a consequence the time spent in classroom is also completed with increasing hidden working time fortunately taken into account with ECTS for the learners; the amount of hidden working time also increases tremendously for the trainers (mostly asynchronous time for individual follow-up) but unfortunately not always fully recognized.

Implicit Outcomes Clarified

LMS offers a means of cooperation towards a personal and collective goal (Millis & Cottell, 1998). It is a way to act upon individual needs summarized in the acronym S.A.C.R.E (Aguilar, 2009); *Security* (reduced risk and fear) - *Belonging* (social group, values...), *Comfort* (feel at ease, facilitation), *Recognition* (positive feedback) - *Personal Development* (mixing the dynamic pyramid of needs by Maslow and the bi-factor theory of motivation by Herzberg). All parties involved should have positive and active attitudes; it is a social group in interaction whose attitude (learners and teachers as a community of practice) can generate knowledge and skills useful in the work

place to create innovation (Hargadon, 2003); a complex vision of social organization. Conducting the course should, therefore, be based on hybridization of means and methods for decided outcomes (Watson, 2001), following the Seven Principles for Good Practice in Undergraduate Education by Chickering & Gamson (1987). Cloud-computing offers more virtual resources with accessibility at almost anytime, from anywhere, for anyone at less cost; it depends anyway on the individual willingness to spread out his own data, to develop and improve contents, to give access or to limit and finally to design his own virtual environment for learning. How to help actors to develop their PLE (Downes, 2012) in order for them to better integrate such tools into the training (requiring specific abilities of trainers and trainees)? Efficiency should be measured at any step from the "artisanal" step of the first experimentation to a new industrialization of training. Stress is put on the joint objectives of trainers and trainees to develop collective innovation (Fillol & Barbier, 2007).

Risks of Increasing Integration of ICT into Trainings

On a pedagogical aspect, ICT are of real interest; a proof could be the tremendous use of LMS that support collaborative work, personal development as e-portfolio to help valuation of experience through on-line life-wide curriculum; web 2.0 software for conceptual mapping to help understanding by reinforcing cognitive links of a specific field with the already acquired knowledge; serious game to benefit from scenarios and practices through virtual environment and group interaction; on-line solutions for distributed collaborative writing or dialogue. Other means (Skype) and social network (Google+, Facebook, Twitter) help interaction outside the classroom and develop group cohesion but with the risk to decrease the sense of belonging in the group (banning attitude) and the level of confidentiality (security). The success depends on four directions to be aware off: *ICT access* versus social class and school status (gender, income and education) (Becker, 2000), *inner ability* with respect to the tool versus heterogeneous public (Fu, 2013), *goal* versus tool and method (T. Wang, 2008), *involvement* of actors (Wang & Kang, 2006). Inefficient ICT solutions, basics skills and low autonomy will lead to a low involvement (even refusal reactions) of learners due to a low benefit energy cost ratio. In addition, however we do think of a connected world, studies show that not everyone has access to broadband connection or material leading to inequality. Teachers are concerned too as they have to fulfill facilities and to train on the tools with respect to their build up innovative ideas; worthwhile outcomes will be a reinforcement of PLE based on transversal skills useful in society and into the workplace; even if this is not the field of expertise of the teacher (Albion, 2001). Such statements were confirmed during ONAAG experimentation for a majority of our public; however, they think and are believed to be efficient internet, mobile or PC users. A higher effort should then be made on posture, mixing motivation and tools. Beyond the technical issues somehow they have to be forced to use ICT through designed progressive situations; motivation for production or getting results is not enough. One has to fight reluctance and resistance to change. First something has to be done to explain "why the tool" and second explanation about the training process too. This necessary act leads to a new culture of learning which is not just competition but giving and receiving, exchanging and transferring; somehow in true opposition to some behaviors observed in society. Finally, such a required progressive pedagogical digital device needs the pedagogical team force, a minimal duration of the training and technical resources. As a consequence, introducing ICT in just one topic seems difficult or of a too high ambition. Regulation has to be done (limiting expectation, supporting experimentation). This is a complex challenge.

A NEW PARADIGM FOR TEACHING

Our experimentation with ONAAG meets the 5 challenges (see Table 1) for Higher Education inferred from Johnson et al. (2014); challenges motivated by the changes in society (higher heterogeneous groups to train with different social class, economic crisis…). The world is complex and one has to understand it (vital necessity) and to adapt to its tremendous and uncertain evolution. Skills can be the clue.

Taking into Account Complexity

In the past, learning was mostly based on behavior approach (stimulus-response principle) dedicated to specific field of knowledge (education). But today a global learning complexity is pointed out (Morin, 2006): efficient learning is not only the addition of separate knowledge but the interaction between them; competences being the "whole" and "the parts" (see Table 2). In addition, the more autonomous a living system, the more dependent it is on the environment it lives in. Autonomy supposes dependency and reliance. Education should help questioning to avoid errors of sureness of knowledge; standing for learning and training. Learning is an open adventure and education role is to give the essential basics to manage complexity; interconnecting knowledge and information. The learning and training processes are complex (see the models in the following) and the PLE, that can support it, is also complex: having access, consolidating expertise and keeping free-choice. This is a social challenge for Higher Education.

Training "Learning to Learn"

To achieve such a goal, instead of splitting apart to understand, one should think about complementing and making links (supplementing); managing complexity ("complexus": what is woven together); understanding is a dynamic process with connections with others and environment. Facing complexity requires autonomous thinking and positive criticism to push away barriers. In reference to the bounded rationality model introduced by Simon (1982), learning is a personal act (choice) based on information and acquired knowledge (always limited) leading to solutions satisfying and sufficient (rarely optimal ones). This refers to complexity of skills through interactions (socio-constructivist approach): learning involves human error and uncertainty. New abilities of the hidden curriculum appear such as transverse skills that can be checked in the Tuning Project; specific and adapted tutoring should develop the "learning to learn" act (Nuninger &

Table 1. Challenge of HE with motivations

ID	Challenge	Motivation
1	moving to a student-centered learning	Democratization of access to university leading to higher heterogeneous groups (knowledge, social class, intercultural…)
2	Integrating the new generic terms for generic, transverse or cross-communicate skills (communicate, analyze, transfer)	The aim is to refer to the hidden curriculum of learning that requires the guiding and individual tutoring to help the learner to acquire the basics of learning tools and methods
3	Aiming employability	To help students enter labor world
4	Supporting internationalization of the Higher education	The aim is to develop mobility and intercultural skills to help learners to face the globalization. At the same time organizations have to evolve to face competitors
5	Training all lifelong	Facing the uncertain evolution of society and its needs is a real complex challenge for anyone, at any age and anywhere to conduct one's personal route

Table 2. The core of the ONAAG Project expressed within the 7 principles of complexity (Morin, 2006)

ID	7 Principles for Complexity	Corresponding Act for the ONAAG Project in the Course
1	Systemic approach (functional)	Functional description of ONAAG (modular design)
2	Hologramatic paradox ("the whole" is made of "parts" but at the same time, all "parts" possess the "whole"; as supplementary parts of it)	Individual and collective activities. Deep knowledge of the group (teacher included) is the "whole" of the skills of the members.
3	Feedback loop (regulation)	Test during ONAAG
4	Recursive loop (adapting)	Assessment, guidance, and feedback during ONAAG
5	Auto - eco - organization - autonomy and dependency	ONAAG evolves (structure, contents) with the feedback from learners and teacher taking into account resources and constraint. ONAAG becomes what the learner will do with it.
6	Dialogic (unifying exclusive notions; as life and death; reunion of two notions excluding each other)	knowledge/skills, off-line/on-line activities, synchronous/asynchronous dialogue, attempt/assessment, failure/validation(mark), personal progression/deadline, free-choice/guided scenario, free-time/working-time, quality/resources (human, techniques, funding), teacher/tutor, teacher/researcher, individual/collective work, cooperation/collaboration, skills/marks
7	Re-Introduction of the "knowledgeable" (expertise, knowledge and skills) in Global knowledge (the "whole"); result from a rebuilding and translation based on known part; making links and interconnections.	ONAAG integrated into the course as a hybrid solution, mixing assessment in classroom and follow-up for a complex validation, respecting the rules (ECTS) of an accredited diploma ONAAG allowing a collective rebuilding of knowledge; generic skills

Châtelet, 2014). These new ways of teaching face cost constraints and lack of human resources to cope with an increasing number of students accessing university. In addition, flipped classroom unsettle public and teachers as they both have to adopt a new posture for a new way of interactions (Clenet 2012); even if it is worth doing it (passive listening/positive action, teaching/guiding…), it has to be explained to actors as commitment and will are necessary. A new paradigm urges teachers and tutors to help questioning and reflexive attitude to develop curiosity (more open minded) and creativity (complementary links) based on personality too. The worldwide interactions are an opportunity to mix ideas and cultures and to modify expectations; developing employability. In this competition world, balance between harmonization and unification should be found to help collective knowledge and innovation. As an example, MOOCs stand for a risk, but also as a new opportunity for flipped classroom; it could be part of the PLE. The recognition of prior experience gives new professional and personal opportunities; all actors and stakeholders should work all together and jointly. Trainings have to be explained and understood in their goals and interactions in and outside the university; in a complementary manner the company should be explained too, in and outside the workplace. As a consequence the trainer's skills can be viewed as three overlapping disks (see Figure 1) leading to a sustainable behavior during the syllabus creation and realization in a given context.

Complex Learning Models

We can refer to the cone of learning experience by Dale (1969) adapted in Figure 2. It is a static pyramidal model in relation with a three-set of learning outcomes (levels): "surface" (ability to define, describe and explain; knowing), "intermediate" (ability to demonstrate, apply and practice; reproducing) and "deep-learning" (ability to analyze, design, create and evaluate; to face complexity and to act in new situations). This model resonates with the learning process cycle by Kolb

Figure 1. Virtuous circle of the trainer's skill for a sustainable behavior

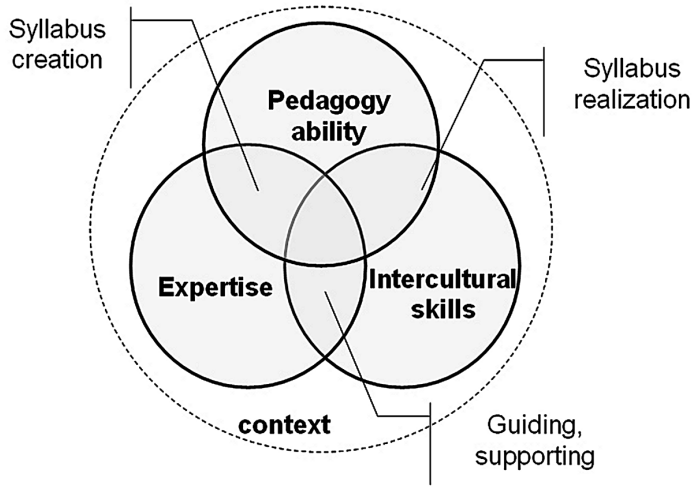
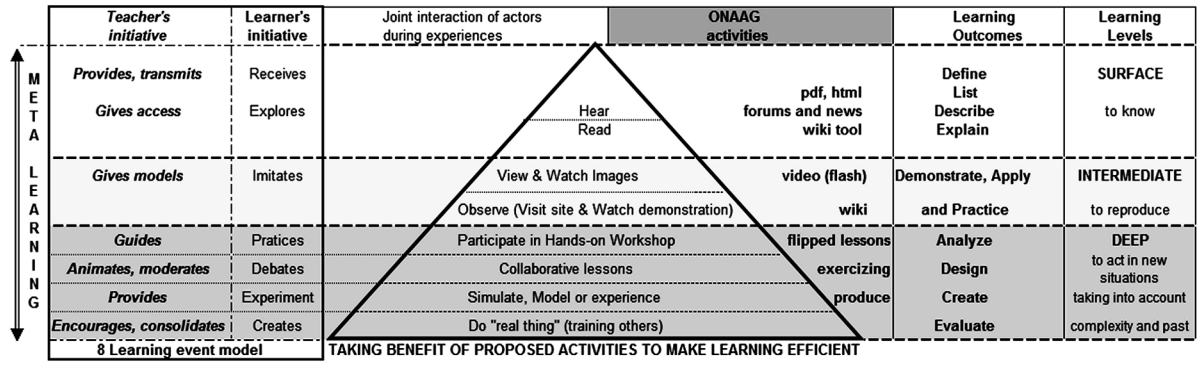


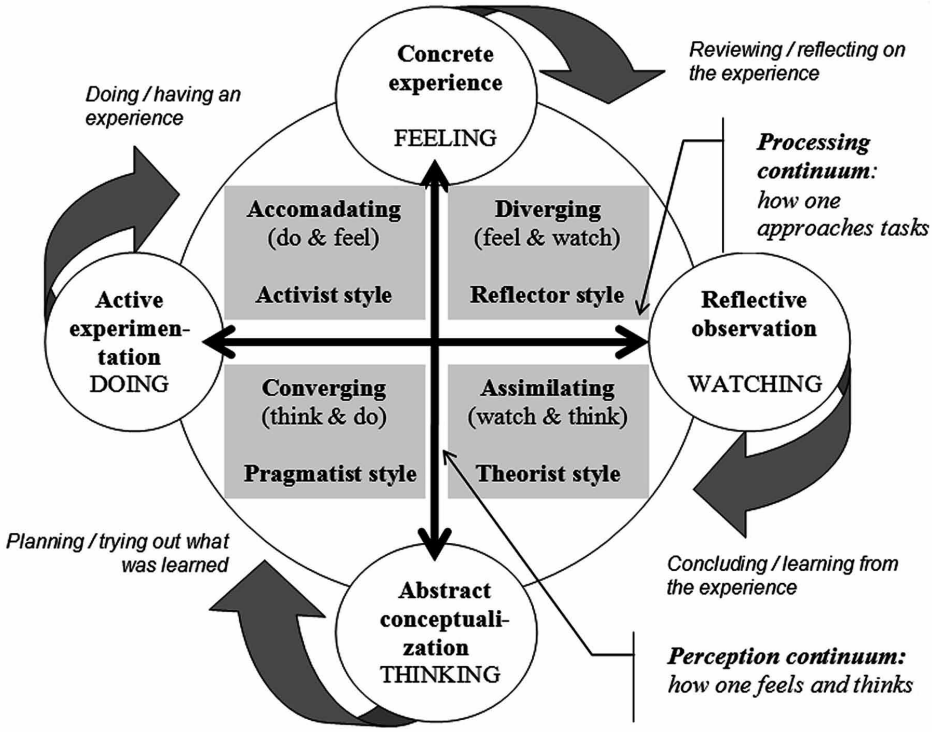
Figure 2. Enhancement of the Dale's cone of experience specifying outcomes and level of learning and the activities of ONAAG (on the right) and with the teacher's and learner's initiatives during learning process expressed by Leclercq & Poumay (2008) (on the left)



(1984) in Figure 3 which is a dynamic improvement process of learning through experience: based on the experience, reflexive observation allows conceptualization, active experimentation and further adaptation based on this new concrete experience. Kolb's cycle of learning focuses on meta-reflection attitude in a given environment (experimental learning) with four stages and two dimensions. Learning comes from the combination of these two dimensions in a continuous and voluntary act to grasp and transform experience (involved, positive criticism while looking back, decision making and perform new experience). Complexity comes from the dialectic of required experience and the will to think about it.

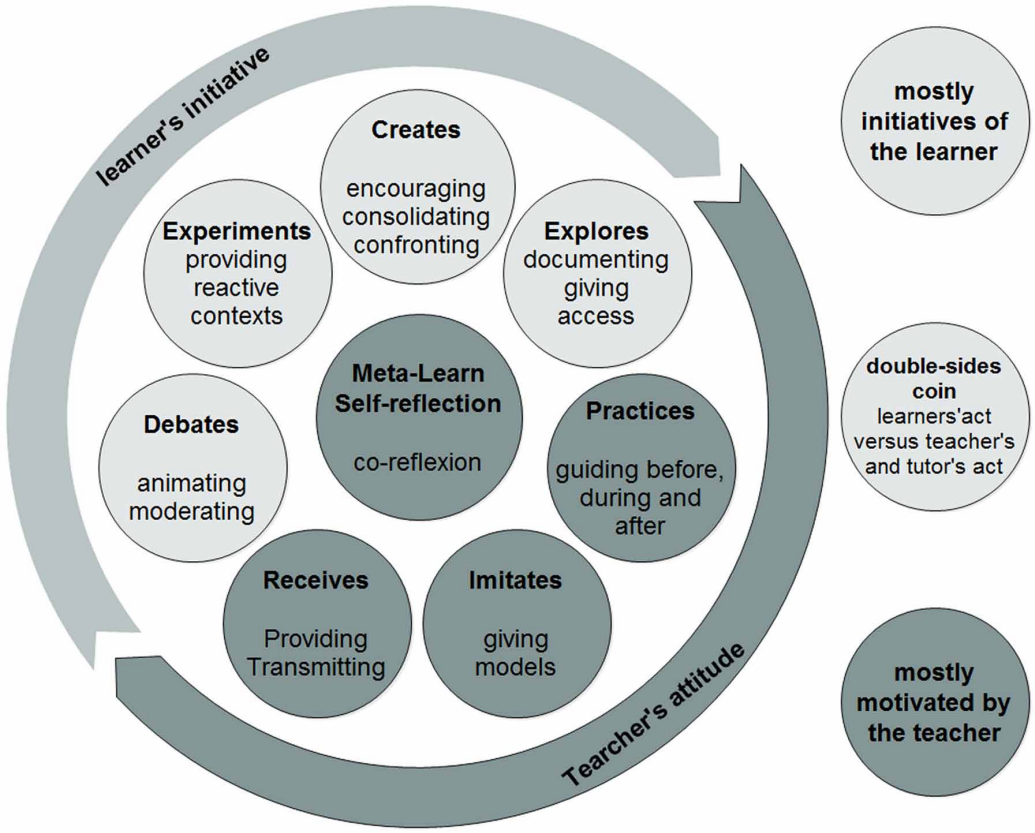
Finally, note the 8 learning events model (descriptive and prescriptive) by Leclercq & Poumay (2008) given in Figure 4. The model is a global learner-centered view of observable learning events (experience) with granular description of situation (disk), with a degree of the learner's initiative that implies or is initiated by the teacher's attitude (they are viewed as paired contrasts), diversity of experiences, generic skills and ethical

Figure 3. Kolb's cycle of learning with the 2 dimensions (grasping: feel/think; transform: watch/do) and 4 stages of experimental learning; styles of behavior are shown in grey background



dimension. It is a joint reality of supplementary actors. The events lead to knowledge (starting the change in the learner's posture) and abilities (meta-reflection to achieve the learning process); learning and training are complementary parts of a complex process requiring interconnections of models. Whatever the model is anyway, learning is a progressive process that can be viewed as a three-loop regulation as shown in Figure 5. The first regulation loop modifies actions with respect to results obtained (observation, reproduction, correction). The adaptive control loop is a more open-minded attitude that requires one's behavior to change the way of actions to achieve goal. The supervision loop refers to meta-reflection enabling one to adapt the framework and his rule in a specific situation to benefit from the previous experiences; it increases the reflexive ability to face uncertainties and complexity when concepts are clear and transposable. With respect to such considerations, the aim of trainers is to reinforce the learning process in a progressive manner and with low cost energy. As a consequence including IT in the process is a reply to different goals. First of all ICT can be seen as a set of tools to help observation/reproduction/correction giving access to examples and several scope. Second, LMS looks like a better means to develop the second loop of learning as a place is given to exercising, debate and creation. Nevertheless, it appears still limited due to the commitment of the trainer in the process and the guiding he gives; but feedback is enforced. Finally, designing a PLE will help the third loop of learning or give arguments to prove that it is

Figure 4. Complex dynamic learning process based on 8 learning events (Leclerc & Poumay, 2008)



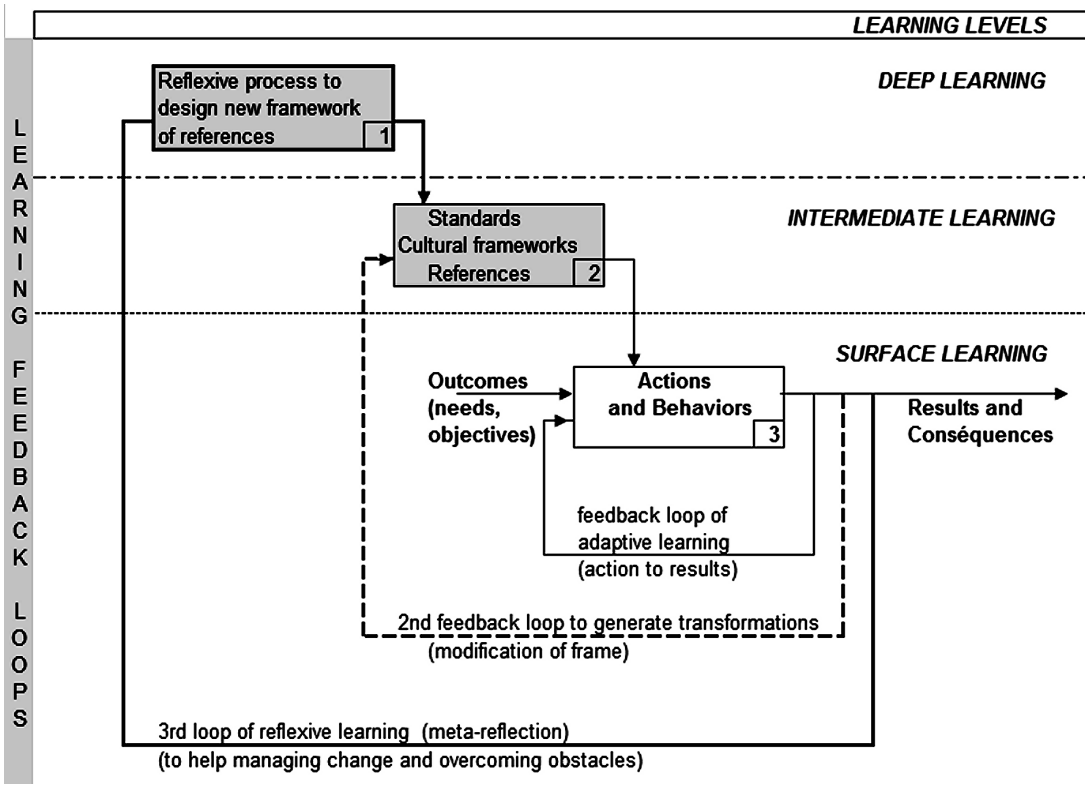
activated: indeed, it is a cognitive construction of ones' personal learning. The more autonomous the learner, the more he is in a meta-reflexive process. These are the motivations of ONAAG experimentation.

LMS VS. PLE: MOVING TOWARDS HYBRIDIZATION OF DEVICES

Learning Management System

The need to data access is partly solved by LMS that stands for a centralized collaborated environment; access is based on specific right within the community (Downes, 2012) and dedicated to education (to share documents, submit and return assignments with asynchronous work). Communication is possible online or offline which is of interest for alternation (follow-up) but LMS required willingness of actors; the teacher being the one who starts the process and maintains flow activity; waiting for production. Advantages rely on permanent access until one quits the community. Practices show, at least in a qualitative way, that learners tend to being less involved in forums on LMS than within personal social network to exchange virtually. Such alternative solutions have no supervision on the part of the lecturer. Enquiries in the classroom show that they prefer to interact with no supervision by trainers, but are they conscious that they are behaving the expected

Figures 5. Three-loop process of learning in real time (learning level are indicated)

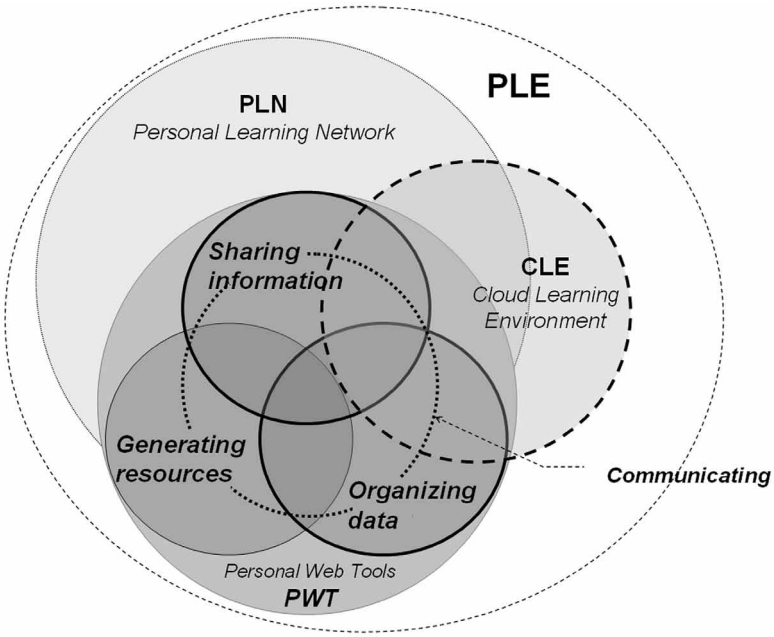


way (with no reliable tools maybe)? Trust must be established (for assessment) and this implies a posture change for each actor.

Personal Learning Environment

PLE stands for a personal construction of e-learning environment based on several ICT media and on the personal way of using it; looking for data and exchanging data through the internet. Spirit is a personal control of one's data (deployment and use in a collaborative open community); learning is possessed by the person (Downes, 2012). This is quite consistent with some kind of Ethics and sustainable acts. Nevertheless, this laudable proposition assumes as pre-requisite that learners have the capacity to work with ICT in an autonomous, aware and advised manner. What kind of position for the lecturer in such a connected environment where he surely does not have control? What about the production he gives access to through the training? How to check the use of it in order to help trainers to make the most from it? It is a global complexity one has to manage. Outcomes of training exceed the field of one topic in the curriculum. As a consequence, learning is not just learning but it is evolving personally, creating one's own path route with Personal Web Tools (PWT); Networked learners (Drexler, 2010) and trainers. A complex PLE model can be built as the "whole" of Personal Learning Network, PWT and Cloud Learning Environment (see Figure 6); a virtuous circle resulting from organized storage and necessary interactions with others.

Figure 6. Complex PLE adapted from Wheeler (2010) mixing PLN, CLE and PWT (virtuous circles with the circle for communication (dash circle in the center))



Requirement for Trainers and HE Providers to Fill the Gap between LMS and PLE

The lecturer should be the one that revitalizes, guides, coaches without imposing his own personal point of view or PLE (surely the main difficult part), training at the same time to and with the tools (LMS he has access to), helping the discovery of new technology and warning about the possible consequences (for the individual own benefit). The European Computer Driving License is required for the learner. HE Providers should also focus on Information Security Management (ISO 270001) to help data exchange and security; as it represents the wealth of the business. Trainers should also be trained for specific media. Indeed, PLE for learners but also PLE for teachers; quoting Downes: "they want your data, they go through you". As a consequence, HE Providers should not master the design of PLE but are responsible for guiding and offering means and opportunity for each actor to build his own PLE. A main question is based on ownership of knowledge. Each one becomes part of a global system and being the system itself; complexity of outcomes. Free choice and autonomy should be required for learners. A contradiction that can only be solved by assuming that the teacher is also a part of the system with maybe the role to initiate process, reinforcement coming from others; learning all together, doing it with our own hands. So PLE could be strengthened if tools are available and the guiding, light and flexible. The teacher is not a model but may be an example; he gives access, offers expertise to facilitate; that should be all. The PLE approach puts in the first place the skill to self-learning in an official and certified framework that should be recognized internationally; meaning that PLE is at the same time all the means given or used by

anyone to build his knowledge and to prove his skills too. PLE make the link between the act of training and the personal learning plans (LLL, CVT), e-portfolio (developed for apprenticeship), competency professional profiles but also self-testing and assessment, cloud, open access to resources… In some way the learner produces like the "*Compagnon*" who creates his master piece to show he is an expert.

MOTIVATION TO DEVELOP ONAAG: A CUSTOMER FOCUS

To Adapt to Developments

Through the years the target students' needs and educational environment have changed and the usual pedagogical solutions seem to lead to partly dead-end with underlying lack of satisfaction. Some reasons for failure are identified (lacks in basics, low autonomy) and specific adaptation of the way to conduct the syllabus tested. Reduced training time and low basic skills are supplementary notions that drive to a paradox between allowing the validation of ECTS for the training module (to graduate) without making simplistic knowledge and diminishing skills (instead of simpler access and higher abilities). The purpose is to maintain accredited deep-level of learning, but to make simpler the educational aspect and to facilitate learning through guiding; taking into account the individual and his interaction with others in a constraint and uncertain environment. The previous experimentations put the context of flipped classroom as a principle to comply with the expectation and constraints of alternation, on one hand, and of heterogeneous group, on the other hand.

To Raise Awareness of PLE

MOOC might be a help to guide individuals to master different sources of knowledge, deciding their own way, but MOOC are already strongly guided online courses. In the classroom, the teacher is the "master" but how to enforce free-choice, develop autonomy and make them be conscious of their own PLE they have to build or are building; a PLE that will be their own all lifelong (Schaffert & Hilzensauer, 2008). Problem is that with not sufficient ICT ability, the means will be alienating instead of liberating oneself; progression should be taken into account. Flipped classroom and secured collaborative environment will support personal development. The pedagogical device ONAAG further presented is based on this perspective of outcomes; it goes further than LMS integrating tools (Mott, 2010). ONAAG facilitates knowledge acquisition without limiting it, giving opportunity to interlace in a group in a production goal (to learn); helping and emphasizing the design of learners' PLE, increasing one's autonomy. ONAAG is of course based on the teacher's PLE to give access to his material. It could be considered as a *Virtual Learning Environment* as partly based on LMS for an identified group, with feedback during the classroom. It is integrated into the syllabus and not exactly a blended device. Through ONAAG, learners evolve alone at their own speed and are responsible for their learning. As a consequence of such will or because the change had already occurred, a new paradigm for teaching is confirmed.

To Integrate ICT as Support for Courses: Teacher First!

Beyond the previous observation stands the will to mix tools and methods for a better (not optimal) solution to face complexity. LMS is already supporting access for resources and information, follow-up and returns of group production but the use cannot be qualified as fully integrated; indeed for the learners LMS of the university looks like a burdensome tool. In the same way, they are reluctant to use the school domain for email and prefer personal private email to contri-

bution in forums; oblivious of their collaborating role in the group (individualism in opposition to inter-cultural). ONAAG will help in the matter integrating several means of education in a secure environment (supervised activities like project, serious game and collective work); *what we call hybridization-based courses supported by ONAAG* to achieve training outcomes. This stands for the mottos "Teachers and trainers first" in reference to Nayar (2010).

To Be Consistent With Learners' Expectations: Learners Second!

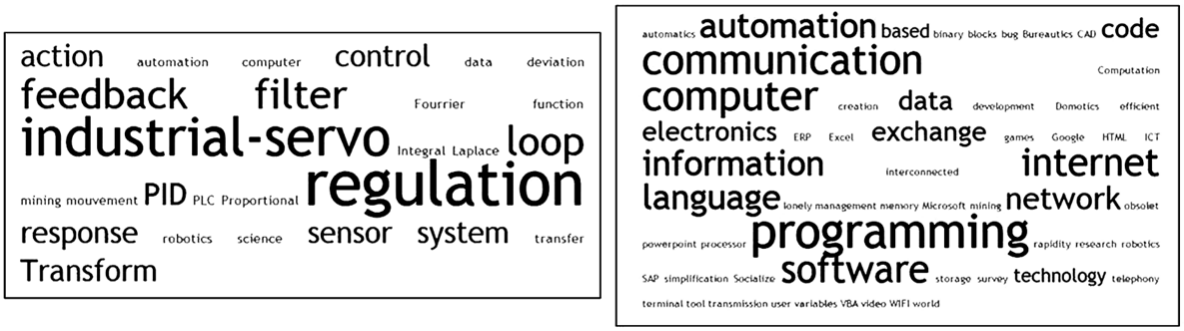
With respect to the groups that experimented ONAAG (see Figure 7) our surveys show that however they have access to ICT the first difference is the low bandwidth connection and the lack of resources outside school: they use professional tools but do not have or want to use their personal computer, pretend and do not know if they have high speed connection either at home. However, they say having computer skills as users, it's obvious that they have lacks in basics (mail, software, forum and behavior). They mostly act as learning receivers instead of learning builders in co-creation (15% find wiki useless after the experiment however they are fond of Wikipedia). Methods should be modified but one can wonder why such a gap between Higher Education expectations to face society needs and learners' own needs.

The cloud map in Figure 8 shows the understanding of groups about a specific topic. Clouds are built using the frequency of word in the reply of students with respect to the words they know or identify in relation to the syllabus they follow. The goal is in the classroom to use these words for collaborative conceptual map building to help the understanding of topic complexity. The cloud map (left) make obvious that the CVT group (employees) are closer to the down to earth words and concrete use of notions; they mostly count on

*Figure 7. Characterization of groups for ONAAG experimentation (*learner's self estimation; **maximum estimation by the teacher based on continuous observation and survey)*

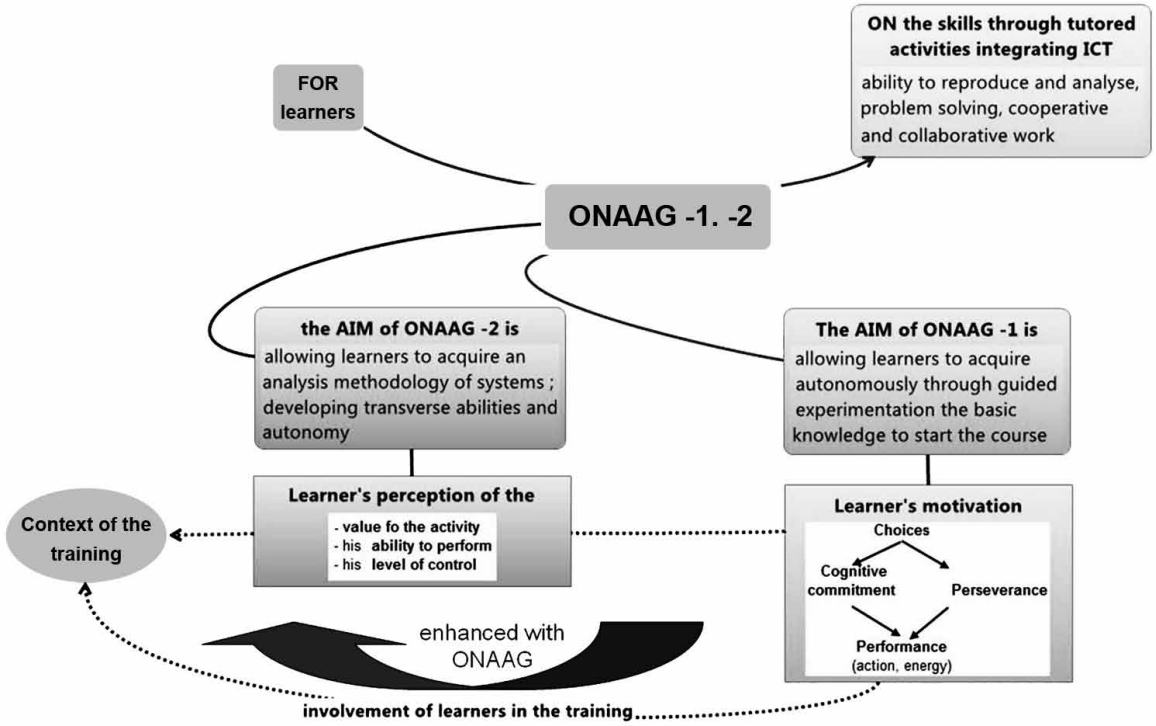
	CVT group Learners	IVT group Apprentices	Full time IT Students
Age (average) **Members (women rate)**	28-41 yo (36 yo) 13 (7%)	21-26 yo (22) 20 (33%)	19-23 yo (20 yo) 43 (77%)
Field of diploma (year in the training) **Topic followed (for ONAAG)**	Production (3rd year) Automatic Control	Production (2nd year) Computer Science	Food Industry (1st year) Computer Science
Interest in the Subject (% true, agree) Topic not perceived as useful Personal expectation for the topic expressed	46% 13% (56% only for knowledge)	87% (no need for it) 41% (needs expressed)	28% 72% (normal involvement)
Personal previous expertise in the topic (level of skills)	43% in Automation (35% technical, 8% expert)	10% (basics in programming)	9% (basics in programming)
Self-estimation of ICT skills (at the beginning) no knowledge, low skills in basics Average ICT skills for users	46%* up to 70%** 100%* medium / 30%**	59%** 41% medium-good**	23%** 77% (9% programming)
Self-estimation of skills in Mathematics basics, simple calculus (needs guiding) pre-requisite minimal level (some autonomy)	85% (15% needs full support) 54% (38% low,8% autonomous)	do not apply	do not apply
Previous Projet Management experience Involved in projects Project Manegement	100% (8% has never animate) 54% (38% as pilots)	100% (as members) Only a few pilots	100% at school (training) do not apply (too young)

Figure 8. Cloud maps based on words selected as relevant by learners (left; automatic control) and apprentices (right; computer science)



their reassuring technical skills. The apprentice (younger) sounds comparatively more general and scholar with more implicit terms. Both publics have, therefore, to evolve in terms of learning posture; going further building knowledge, searching for sources to explain notions. This requires that the teacher initiates the motivational dynamic process (see Figure 9); this stands for the mottos "Trainee second".

Figure 9. Bull chart for ONAAG (top half) that gives the training context in order to enhance (lower part) the motivational dynamic process (Viau, 2003) for efficiency and commitment of learners; motivation with ONAAG-1 (basics) and perception with ONAAG-2 (ability)



PROJECT MANAGEMENT TO DEVELOP ONAAG: A QUALITY CONCERN

ONAAG Project: Leader's Responsibility

Achieving outcomes (success), requires a customer focus, continuous improvement and leadership, taking into account the constraints. Learners and trainer (the "clients") are part of the development process taking into account interaction of developer and users. The consequence is that the group is not simply a studied one with a proposed activity but the supplementary actor that creates and makes the "product and activities" ONAAG evolve during the course for quick adaptation and compliance to expectation perceived and expressed. ONAAG structure is modular to allow quick validation and progressive deployment with other groups benefitting from factual measures of profitability nature; ensuring welfare of mutual interaction between actors during and after the training, synchronous and asynchronous. This is a value management point of view (ISO 9001:2008) whose principles are summarized in Table 3. It is a complex strategic-based issue leading to the process map given in Figure 10. Learner's needs (graduate, assessment, employability) and teacher's expectation (welfare at work, efficient work and sustainability) will be satisfied; benefitting from previous training and work experience, existing LMS and other pedagogical tools in the course.

ICT should guarantee accessibility of training to all with respect to European Standards; this implies the use of certified tools to free the syllabus and curriculum design from the technical aspect on which it is based on; two technologies are used as will be described later on. The action plan is given in Figure 11 with monitoring indicators indicated in Table 4. Local and global environment are considered for strategic issues; such as university rules, stakeholders, update of professional profile of competences. Monitoring, assessment, communicating and transfer are required to give value to ONAAG. In the following, the results for the CVT group are mainly focused on.

Table 3. 8 principles of management applied during ONAAG project

ID	Management Principle	Motivation and Explanation
1	Customer focus	Learners want to graduate through objective assessment. They wish employment. Teachers want welfare at work and efficient courses. They expect transversal skills too. Stakeholders (university, company) want compliance with constraints and developments
2	Leadership	Teacher initiate, animate and revitalize group
3	Involvement of people	Trainers and Trainees co-create learning through collaborative activity
4	Process approach	Modularity, progression of phase, step in the individual route in ONAAG. Identified process with indicators for the production process, the teacher's expectation and impact on learners
5	System approach to management	Mixing culture and practices between actors through activity and feedback
6	Continuous improvement	Permanent corrective attitude during the upstream of the project, during the realization and integration into the course and after experimentation. Identification of improvement perspective and deployment if valuable.
7	Factual approach to decision making	Follow-up of individual route and collaborative group activity during ONAAG make assessment more unbiased. Pre-enquiry about learner's needs and post-evaluation are profitable acts that limit interpretation and subjectivity.
8	Mutually beneficial supplier relationships	Friendly attitude, flexibility and listening allow perception of low signal to detect and alert. Commitment for activity. Words are released.

Figure 10. Process map to conduct ONAAG project

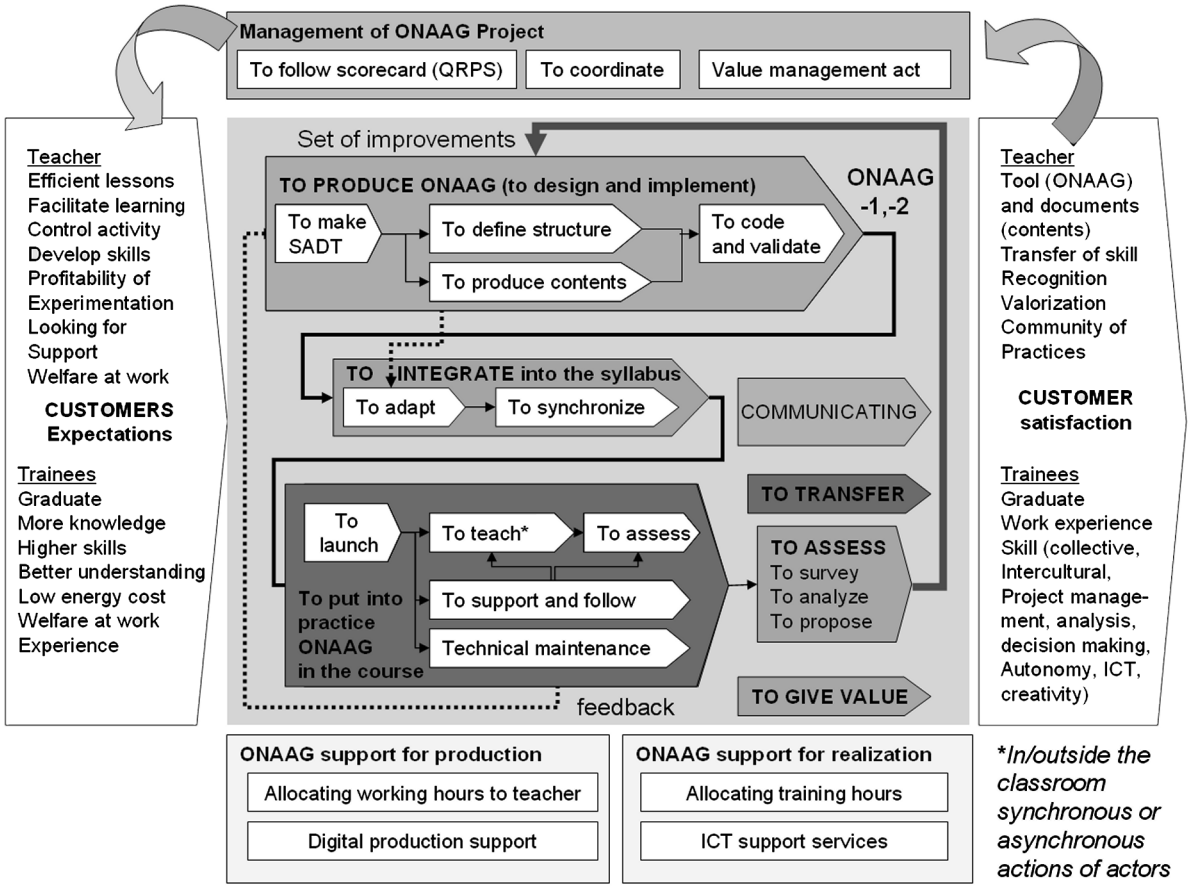


Figure 11. Global mapping of the action plan for ONAAG

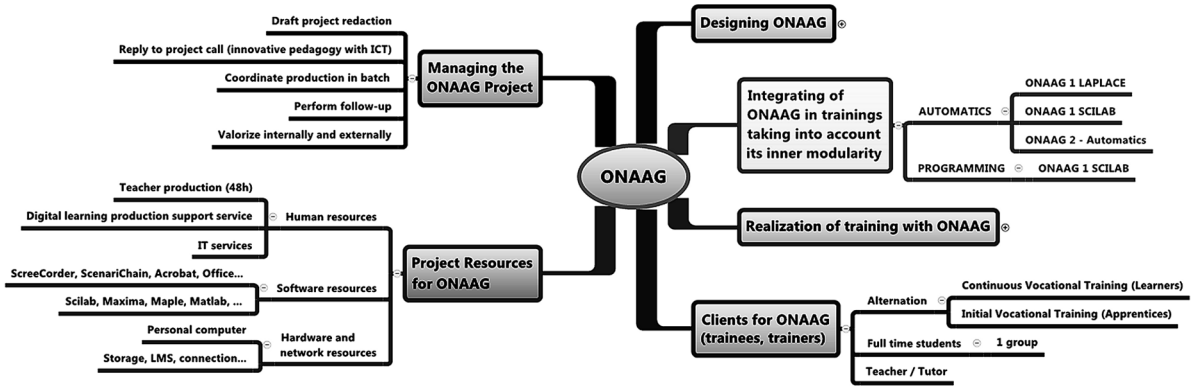


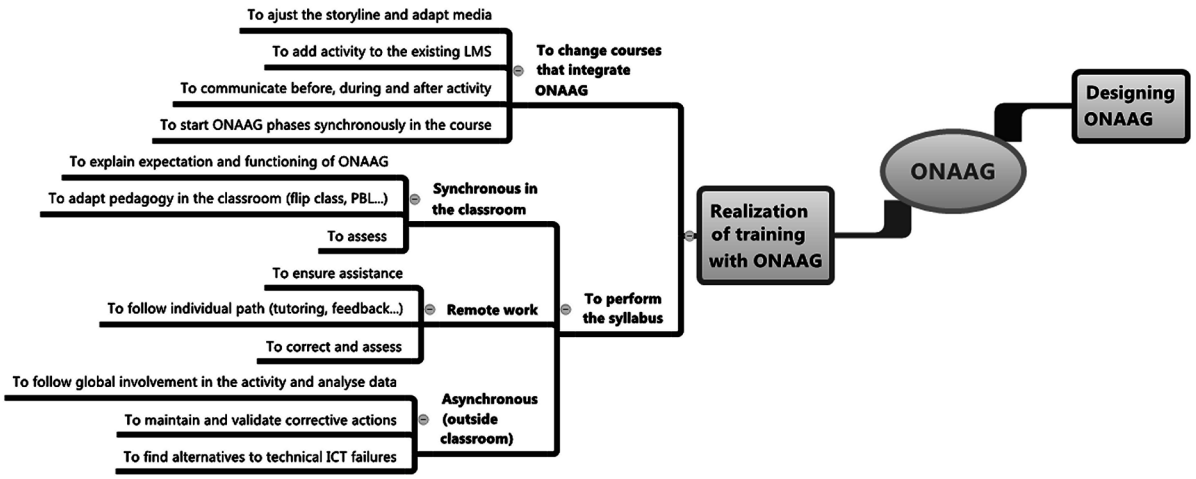
Table 4. Some indicators of different natures (rows) for ONAAG with three points of view (columns)

Nature of Results	ONAAG Project (Process)	Implementation of ONAAG (Teacher)	ONAAG's Impact (Learner's Outcomes)
Quality	• Availability • Structure not relying on topics • Assessment processed • ONAAG respects expectations	• Modular design respects outcomes • Compliance with teachers' PLE • Assessment	• Each course starts with feedback • Group produces, innovates and debates • All bugs reported receives a response
Profitability	• ONAAG based on the CMS of the university • ONAAG is adaptable to events • Asynchronous support exists • ONAAG is transferable at low cost (adaptability)	• Learning facilitated (classroom) • Better commitment (activity) • Follow-up, asynchronous feedback • Positive attitudes and proposals • Only skills on LMS is required	• Personal respect improved • Autonomy, collaborative skills increased • Ability to learn (higher) • All trainees have completed all activities proposed by ONAAG • List of proposed improvements
Security	• Follow-up of individual and group is possible • Traceability of events	• Teacher masters contents and setting • Met the teacher's needs (PLE control) • Students are identified when connected	• Traceability of exchanges and debates • Questions are formalized and released • Individual follow-up • Minimal expertise before the lesson
Reactivity	• Action plan respected • ONAAG available as scheduled • Maintenance available	• Forward of alert is possible • Quick changes possible on line • Progressive implementation	• Dynamic and collective dialogue • Involvement of learners • Learners' reaction to solicitation

Action Plan for ONAAG Project: Manager's Responsibility

Processed by the trainer, a simplified mapping of ONAAG project is given in Figure 11 showing the global complexity: Managing, Designing (developed in Figure 15) and Realizing (in Figure 12); Clients are indicated with the Resources for support (financing through working hours and material). Integrating ONAAG requires previous ICT skills for actors; for the teacher, mainly with previous practices as it is a factor of motivation to integrate ICT in the course. The design is based on functional analysis followed by the selection of material and information for contents. During the realization, synchronous processes (online

Figure 12. ONAAG realization; developed map showing hybridization in the course



or in the classroom) and asynchronous processes (off-line, individual autonomous work and collaborative production with feedback) are interlaced. The purpose is progression but also changes in activities to maintain high level of energy and commitment. Therefore, actors have to make the best use of ICT to produce and develop interaction to achieve the complex goal of learning by and through collaborative and individual activities. Integrated ICT in hybridization-based courses is not simply a technical problem but also a reply to how to appropriate a new teaching instrument.

Dynamically Integrating ONAAG into the Course: Pedagogical Act

Due to regulation requirements during realization (see Figure 12), the development process for creation and integration of ONAAG followed a DMAIC methodology to improve the device while being processed. The action plan requires scorecards for results of different natures: *Quality, Security, Profitability* and *Reactivity*. Indicators are given in Table 4; some apply to the creation process (the project), others rely on the teacher's expectations and, finally, some measure the impact of integrated ONAAG on learners (for a hybridized-based course). The measures and the matching corrective actions decided during the project are further given in Figure 22. The Lean stresses the just-necessary processes along with the living reality (minimal funding, reduction of official available working time, random dedicated personal time to the training).

It is important to notice that the ONAAG structure is evolutionary; surveys before and after are made to adapt the design, but also a continuous feedback is made all along the course. The experiment phase allows the identification of resource lack or availability, then the contents to adapt and finally the assessment aspect to design an expected autonomous route.

Design of ONAAG: Teacher's Responsibility

From the point of view given in Figure 9, ONAAG is conceived as a modular structure (ONAAG-1 and ONAAG-2) corresponding to a progressive asynchronous learning of required knowledge and skills (see Figure 13) further used in the classroom (synchronous) as shown in the conceptual mapping of ONAAG (see Figure 14) in interaction in the course and environment (fully integrated); the links between the improvement process and the actors' outcomes and collaborations are shown. The complexity of the graph relies on the interactions of the triplet Project-Management/ONAAG-Techniques/Hybridized-courses.

Figure 13. Example of learning outcomes for the module Automatic Control (CVT) linked to ONAAG

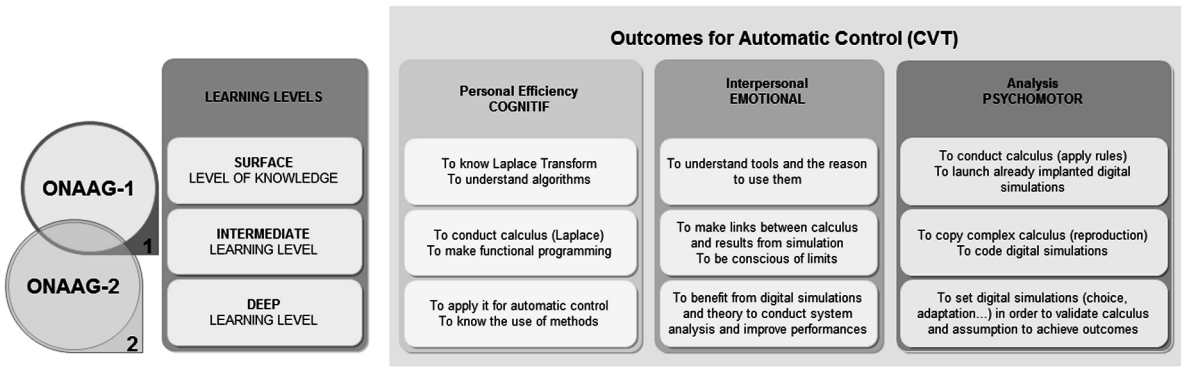


Figure 14. ONAAG conceptual map; project management (on the left) with modular parts (on the right)

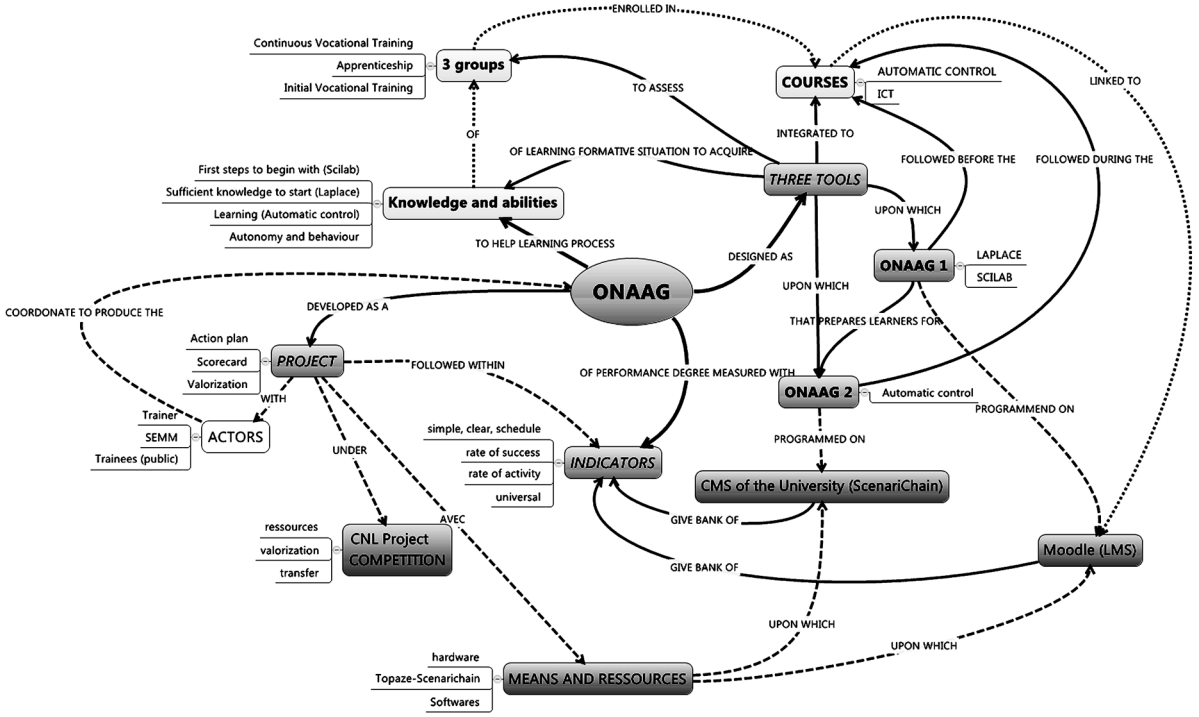
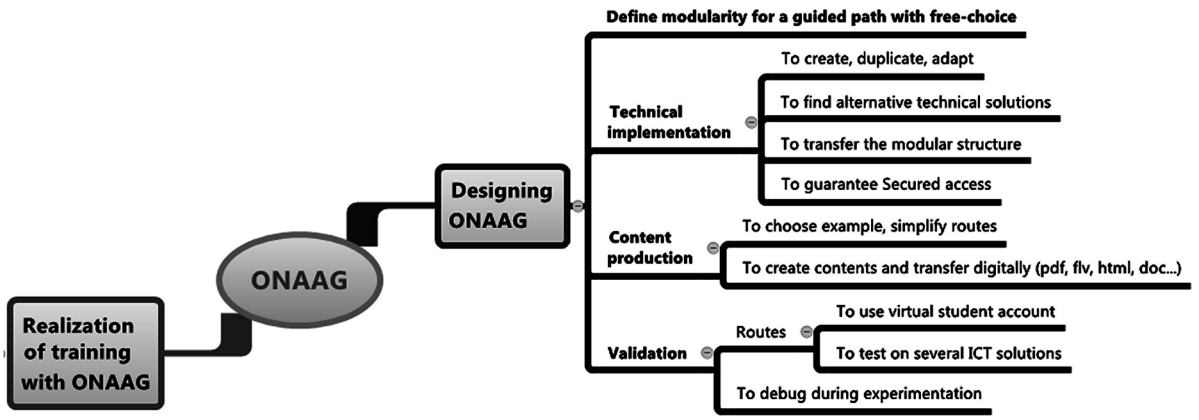


Figure 15. Developed mapping for the action of Designing for ONAAG



ONAAG is dynamically integrated into the hybridized-course and adapted all along the training thanks to continuous feedback (through qualitative observation by the trainers, listening, positive criticism, enquiries and results of learners). Through its modular design and use, ONAAG's aim is to strengthen impact of courses for efficient use of the actors' energy in the training; the indicators such as well-being in the training, commitment in group and individual activities, and positive criticism are considered. With respect to temporality in the courses, step 1 is ONAAG-1 designed as an automated and generic scenario that can easily be applied to specific topics and adapted to the public

encountered (see Figure 16). It is implemented on the LMS Moodle using the classical resources of the IT platform and with the same usual logic for training. The solution allows consolidation of gains already achieved in the field (surface level of learning) to facilitate training (discovering new concepts, being able to reproduce). The activity is a dictated path through knowledge broken down into levels (made accessible with respect to each learner's completion of activities) with guidance. Besides, sequencing gives increasing autonomy in the use of LMS but mainly in individual organization all along the training for an allocated time, as learners identify their own difficulties, can adapt and then be prepared for step 2.

The second step, ONAAG-2, is created in a dedicated workspace for case studies built from the editorial chain Topaz (ScenariChain) designed with several paths to be followed autonomously (see the Structured Analysis and Design in Figure 17). This skill-oriented solution is based on a different logic for training (intermediate and deep learning levels). The learner will have different attitudes during the process like passive reading (blocks A2, A23 and A35) and active listening (A31, A36 blocks). The decision making block A21 leads to a personal analysis based on free-choice; quiz (A23) allows the control of results. An automatic guidance is available with respect to learner's proposals, results and assessment (A35, A36).Learners need to implement external means (calculus, simulation, communication and organization) for peer review through cooperative work. In this way, the first two loops of learning are activated. But it is the synchronous integration with flipped classroom that develops autonomy and more collaborative attitudes. Feedback by the trainer is done to avoid dead-end; answers and additional help provided under the constraint of voluntary questions with arguments. Indeed, the objectives are to involve the group in and through activities (in class or remote) and motivate learning to develop their employability (autonomous, adaptable, innovative improving). Their final production will be a full report of experience with their own conclusions, results, arguments and proposals that will allow validation of the group's expertise.

Finally synchronization between ONAAG and courses is made through LMS (see block L1 in Figure 18); showing the complexity (hologramatic principle) of the set ONAAG-1 and

Figure 16. Phasing of ONAAG integration (3 groups, 2 modules)

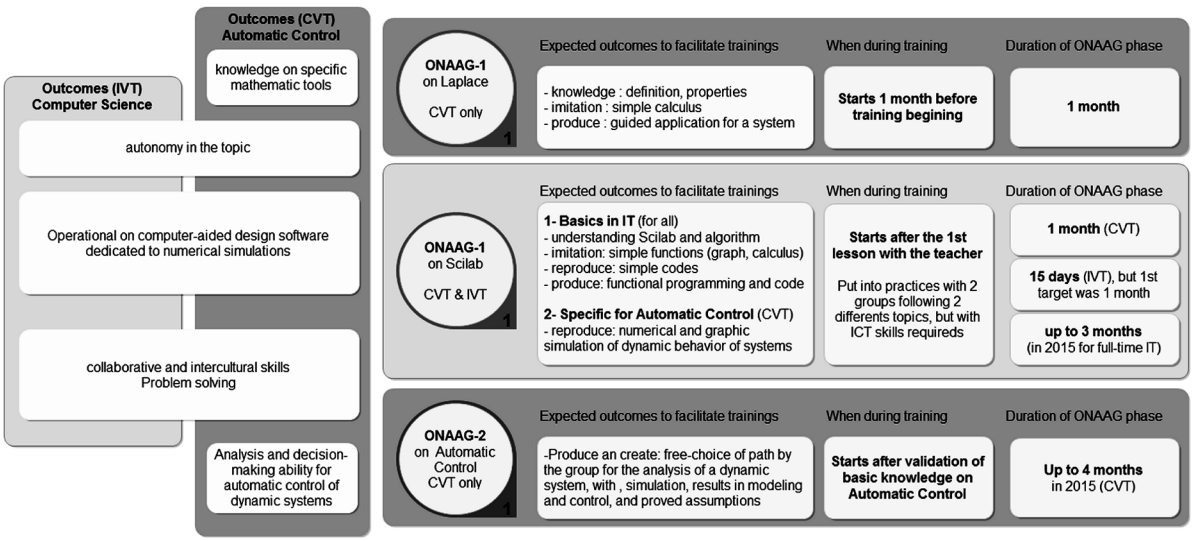


Figure 17. Simplified SADT of the complexity of ONAAG-2 (activated when ONAAG-1 is terminated) with one free-choice route developed (A31-A36)

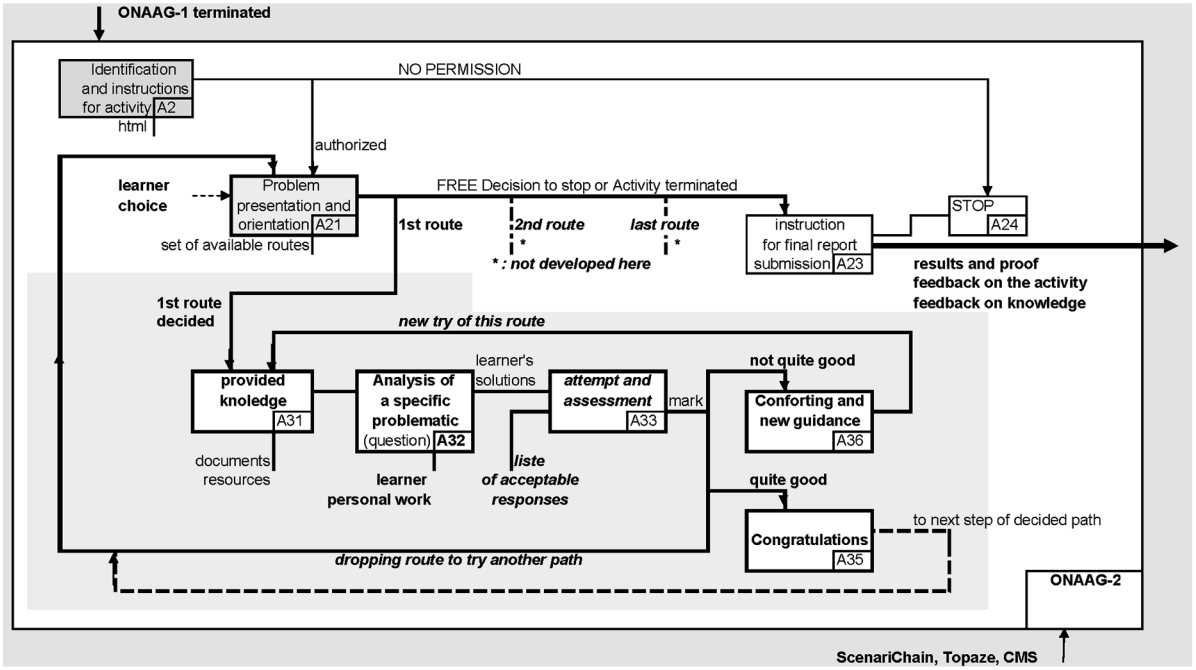
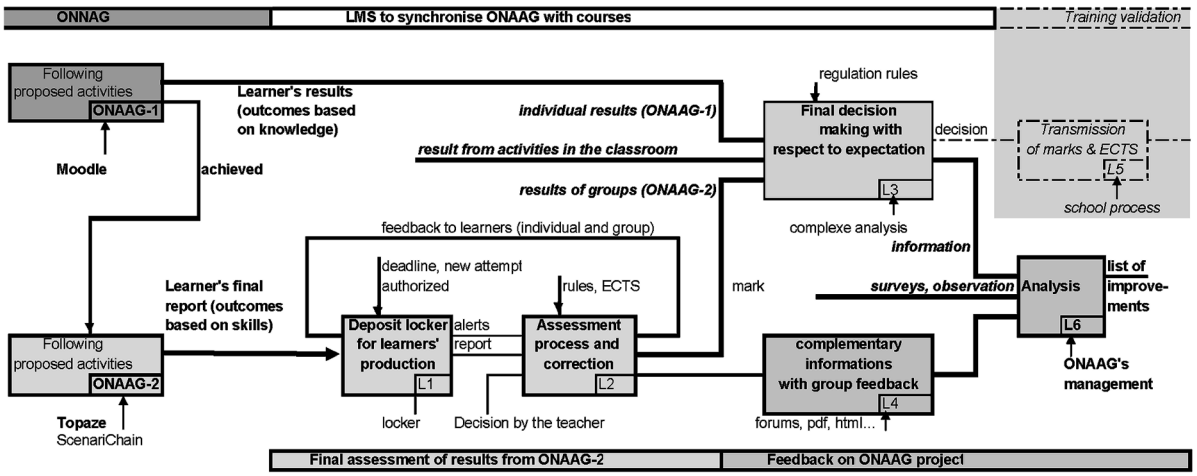


Figure 18. Simplified SADT of the complexity of ONAAG project with final assessment (L1, L3) and further feedback (L4, L6)



ONAAG-2 with the LMS, the assessment (based on several factors: activity achievement, evolution with change during learner's route, quality of conclusion and argumentation) and dialogic guidance (comfort, reassuring) processes performed by the teacher. In this way, the structure allows DMAIC; Define (identifying the need), Measure (success and failure), Analysis-Improve

(guidance and feedback for new attempts) and Control (free-decision of learning path; the way the problematic is studied, analyzed and solved). The way to solve complexity is not unique and neither are the solutions; only average values of results to calculus are tested and decision is only compared to a set of acceptable conclusion (with respect to knowledge). Final validation of ECTS for the module is performed through a complex process (L2, L3) based on 3-set information that complies the regulation rules of the school and the professional profiles of the training (Nuninger et Châtelet, 2014); sustainable combination of learning levels upon a batch of skills: personal effectiveness (cognitive; measured from individual work, feedback, commitment), analysis and realization (psychomotor; proved by identified personal and group production), management and influence (emotional; observed from follow-up and involvement in the work and learning environment with peers). Note that the LMS (Moodle) is only one way to support a centralized environment of collaboration with specific right within the community. The block L6 allows the global analysis of the impact of ONAAG project.

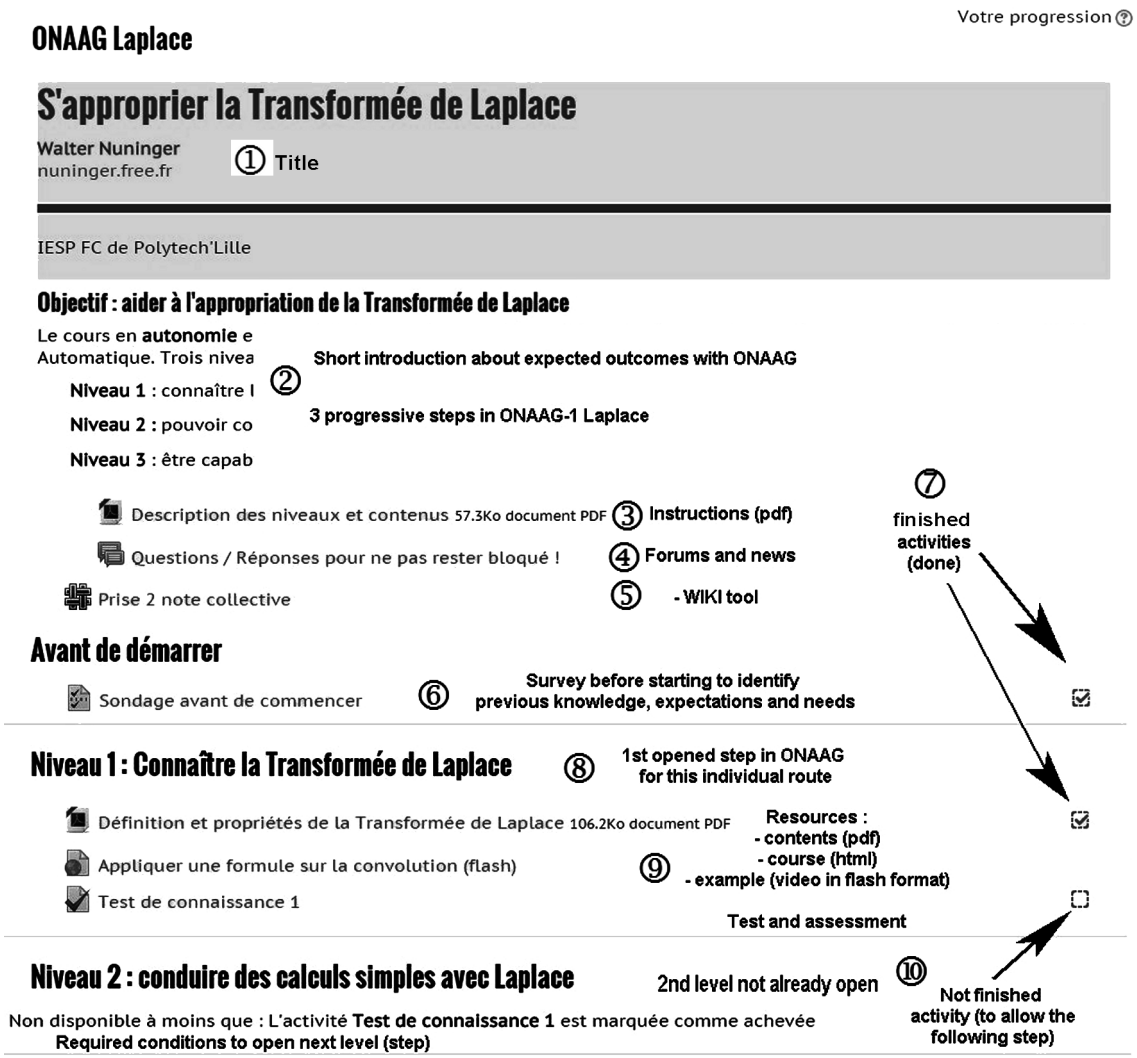
FIRST RESULTS OBTAINED AFTER EXPERIMENTATION

However, the structure and use of ONAAG is clearly framed (mapping of scenarios, assessment procedure) the learning becomes more informal by the use of the device because the personal route remains entirely free (no unique solution, free decision about means, priority and energy cost), but can benefit from multiples resources. The added value of the pedagogical device ONAAG is to help ownership of knowledge and skill development: collective work ability, positive review, project management and problem solving by taking advantage of past experience and ICT skills. As a qualitative observed result, revitalization tends to be obtained for a majority of the group and higher involvement of the learner in the field too; even if their first interest in the topic is not so high (topics are imposed by curriculum!): the third loop is activated and favored through ONAAG thanks to functions performed by the learner during operation. Some screen copies are given to illustrate ONAAG-1 based on LMS. In Figure 19 the screen viewed by the learner is shown with resources (1 to 5) and modular activities (9; lessons, survey and quiz) that open with respect to personal achievement (7; ticked boxes); one section is activated (8) and one still closed (10). Note that ONAAG-2 is based on a completely different rule for progression and different technology (hypertext, javascript and css); a more complex structure mixing resources and tests with free choice of route (see Figure 17 with only one path developed to maintain readability).

An example of a screen viewed by the teacher (see Figure 21) that reports on achievements (left) with full administration panel; to keep a high level of motivation, badges of success can be issued (right). The added-value is brought out by the trainer with the involvement of the trainees in the learning process. One of the risks identified is an attitude of trainees that can be considered to be too academic leading to a minimal review of concepts driven without much ownership.

The return on the current experience, after 8 months (2 months to design and build the project and 6 months of operation) with feedback and feed forward was shared with the co-author and colleagues for technical support in digital production and maintenance. It is based on continuous observation; surveys before/during/after, follow-up and assessment (gap measuring), qualitative and quantitative enquiries, voluntary propositions of learners as a reply to open questions, personal feedback of the leader-researcher/designer-developer/teacher-tutor and proposals by two groups (CVT and IVT; see Figure 7). Some debates with the groups allow adaptation and framing of expectations during the timeline, taking into account their hidden constraints (other requirements, previous

Figure 19. Commented screen for ONAAG-1 during individual process of learning

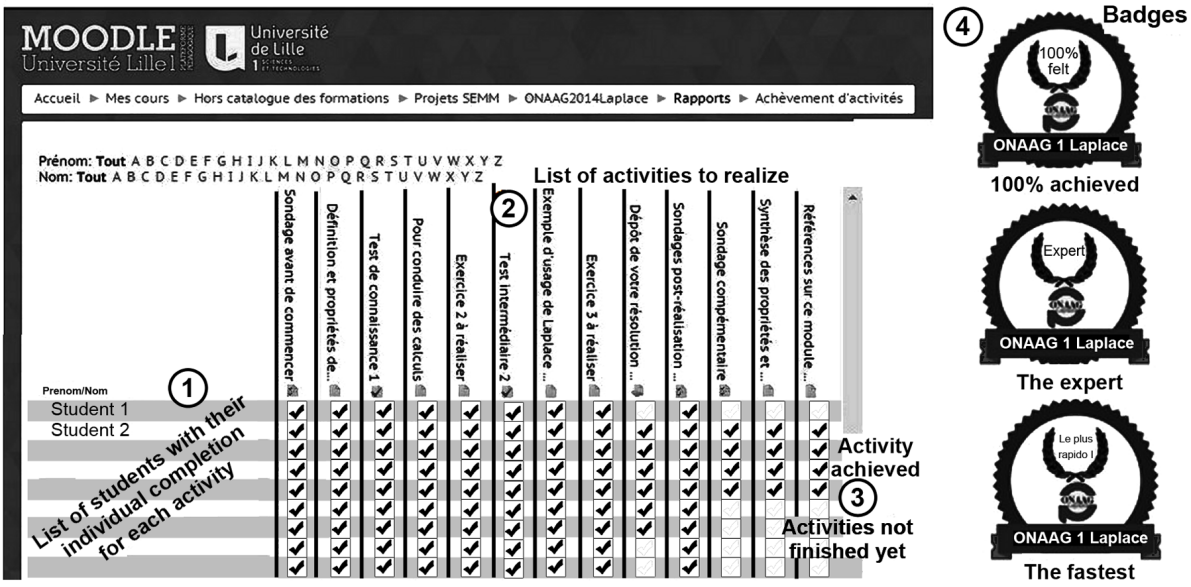


skills in ICT, anterior knowledge and low consciousness of their PLE…). Quantitative results are given in Figure 20 comparing the information at the beginning (Define and Measure of DMAIC) and after (Control); the main result is that some implicit needs of learners were revealed during the process (27% of the group). In that sense ONAAG allows the learner to be aware of topic finalities and of their own responsibility in the act of learning. Qualitatively speaking, the follow-up of learners shows that they make several attempts to solve problems; trying to understand better, thanks to guidance. Some learners focus on marking; that is why some changes were made introducing descriptive grading like "fairly good", "good"… or "done"/"not done"/"to be done" instead of marking with numbers by default. Finally after ONAAG-1, the groups were expected to meet the requirements for validation of ECTS corresponding to the first semester; a continuous observation confirmed by the better results of each group to the final assessment in comparison to the former

Figure 20. Results of survey after ONAAG-1-Laplace (CVT group for Automatic Control)

BEFORE the learning	Indicators	AFTER ONAAG's activities ONAAG-1 Laplace
100% use PC and internet 13% has minimal skills 7% do not know what is a WIKI	ICT Skills	23% had difficulty watching video in flash format 85% read WIKI (15% found it useless)
38% self-estimate their skills as low ones (calculus)	Skills in Mathematics	73% found the topic (and quiz) difficult 65% because of their previous level in mathematics
60% do not expect much of it	Interest in ONAAG	67% found that the activity met their expectations (47% partially, 20% entirely, the others has no needs)
does not apply	Design of ONAAG	67% found the modular progression convenient 39% are satisfied with assessments
does not apply	Documents, ressources in ONAAG	63% are satisfied with documents (global quality) and format 8% has not read all resources proposed
Almost 100% use LMS (mostly, just to access information)	Technical aspects of ONAAG	62% are satisfied with video (global quality) but 40% found the duration too short. Mounting could be improved (47%)

Figure 21. Commented supervision screen of activities for the teacher (left) and badge (right)

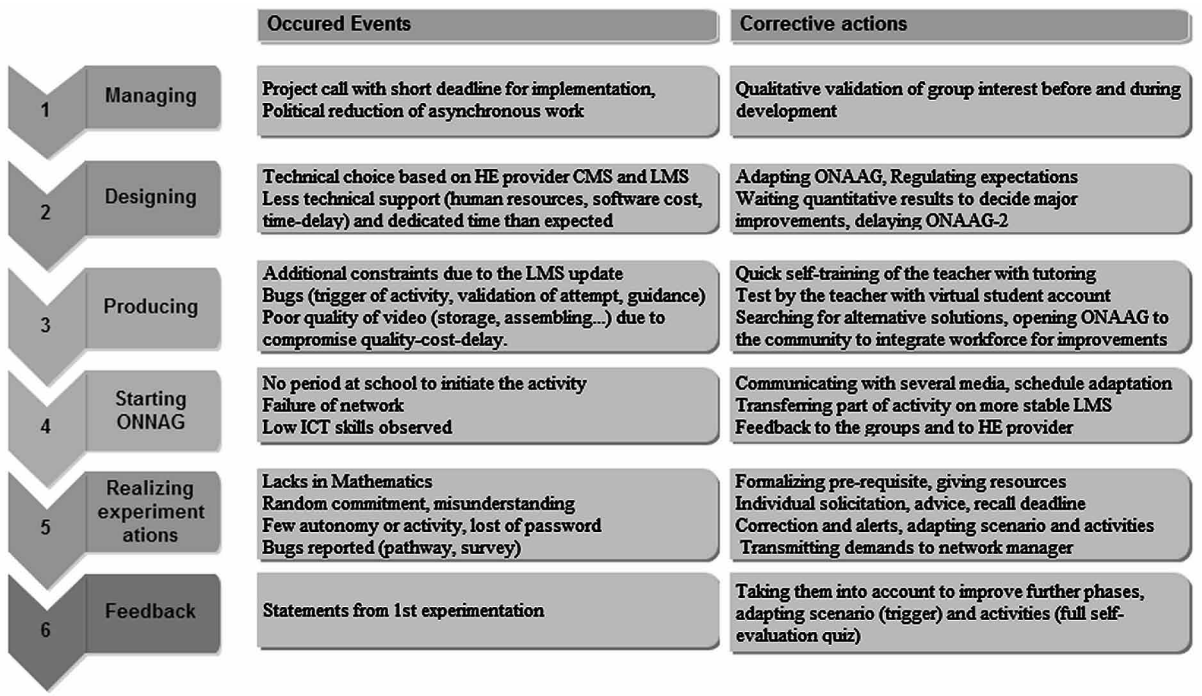


promotions in 2013 not concerned with this pedagogical device developed in 2014 (in 2013, only half the group enrolled in CVT took the final test at the first attempt, 50% required additional work to succeed; in 2014, 77% succeed immediately and additional work only concerned 23% of the group for success). Note that only 54% of the IVT group fully achieved the activity that requires much more explanation about ONAAG's aim (100% for CVT; learners estimate an average of 15 hours to

achieve ONAAG-1 with deviations mostly due to insufficient pre-requisites or lack of autonomy). We can quote the following significant statements by the learners: "the device was interesting as I can learn notions at my own pace", "for complex notion we need more tutoring", "Feedback is worthwhile in understanding the aim of the activity", "I took pleasure trying to solve the bugs in my code to pass the quiz". We quote a change of posture but a change that is harder for those with less learning ability: "I need more lessons in class", "I want the solutions in pdf format", "I don't like forum and prefer personal email", "too many documents to read" which is surprising for a learner enrolled in a work integrating training.

Corrective actions during process development are given in Figure 22. All along the process, in the classroom a feedback is made with respect to identified difficulties or word released. Progressive activities of ONAAG facilitate the beginning of course and permit immediate operational effectiveness. In the hybridized-course small serious games are used to allow quick and simple discovery of standard for functional analysis and algorithm; developing interaction and group cohesion, motivation. Energy in the classroom focuses on the application of knowledge in new situations and to go further with respect to the topic. Debate allows appropriation too. ONAAG becomes the media to make alive the mediation relation of actors (trainees/trainer) with knowledge in and outside the classroom. Memorization through understanding and cognitive relation is a complex human process needing sensorial stimulus, selective focus with analysis (immediate memory) but also repetition of experience, active behavior (action) with interaction (reply) for long-term memorization. ONAAG fit the gap for the given course. Considering the 8 learning events model, ONAAG solution allows the learner's initiative (exploration, creation, experimentation, debate and meta-reflection) under teacher's initiative (practice, reception, imitation). Indeed, the mix-solution ONAAG is center positioned in the decision management matrix for

Figure 22. Some events occurred during ONAAG implementation and corrective actions



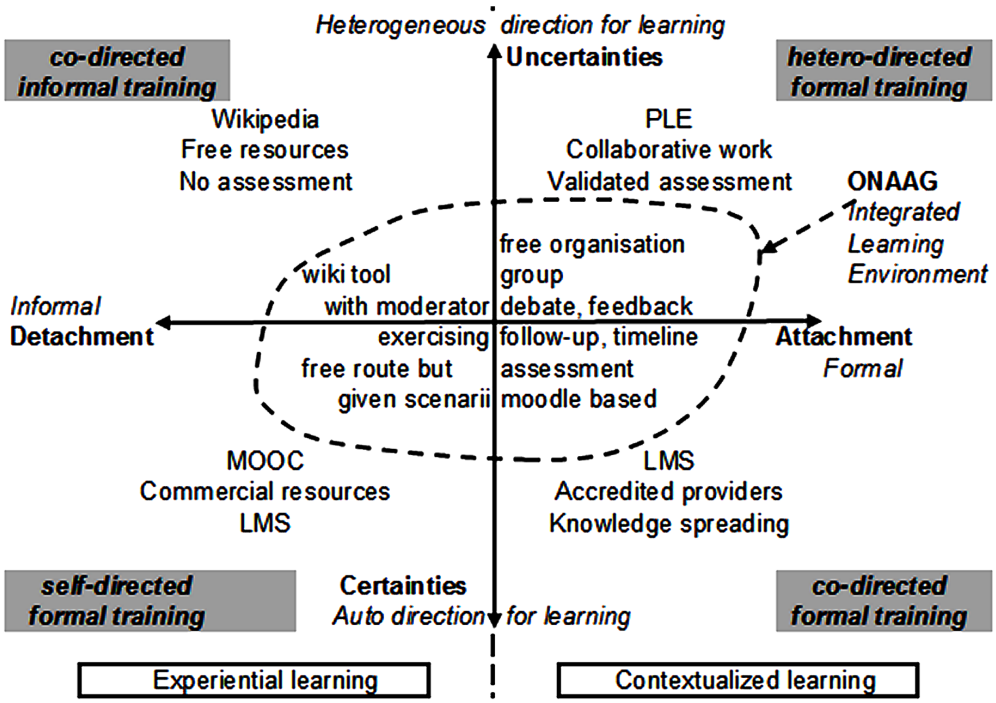
learning solutions integrating ICT (see Figure 23) and makes consistent the dialogic directions of learning devices. ONAAG can be seen as a sustainable solution, as it covers contextualized learning (formal co-directed and remote training) and experiential learning (formal self-directed training but also informal within companionship and guidance). This not-simple solution is an attempt to solve the paradox of developing PLE (to help learners to face complexity giving them possibility of autonomous choices) and at the same time maintaining involvement in the training (respecting constraints of accredited training through more control or regulated IT tools). On the first hand it helps learners to face complexity giving them possibility of autonomous choices for themselves and with others. On the second hand a framed and mastered environment are given with respect to accredited training criteria through more control or regulated IT tools. This choice allows compliance of ONAAG with the motivational dynamic process during learning by Viau (2003) as shown in Figure 9.

PROSPECT OF THE ESSENTIAL PRINCIPLES OF QUALITY

Total Quality

With respect to the Guidance of Quality Management System (ISO 9001:2008, see Table 3) trainees and trainers are in the center of ONAAG's development (process approach) to comply their

Figure 23. ONAAG solution placed in the decision management matrix of learning solutions integrating ICT; a compromise between commitment (horizontal axis) and complexity (vertical axis)



expectation (customer focus): skill development, optimal transmission of knowledge and skills for the syllabus, individualization and support. ONAAG reveals the trainer's will to design, create, put into practice, initiate and follow (leadership) and asks for the involvement of all (actors are part of individual and collaborative process of learning). With respect to the standard for Occupational Health and Safety Management Systems (OHSAS 18001:2007) the interest of the trainer in the approach that motivates, and support is also integrated; a point of view that leads to including trainers as clients, too. Interaction between trainees and the trainer is important to develop efficient learning; that complies the Guidance on Social responsibility (ISO 26000:2009). It needs good relation between teacher and group (mutually beneficial relationships) based on a negotiated and accepted contract with respect to expectations and rules in the classroom (the instructions in ONAAG, the explanations of functioning and explicit requirement; evidence-based approach). Active listening between the actors and positive criticism should be processed to initiate and strengthen involvement; alert and feedback (continual improvement). This might be proved with theses quotes by learners in CVT: "Very pedagogical approach even if there is a lot of information and notions to learn", "I am not a programmer but I am satisfied with my results", "I took pleasure solving quiz", "Thanks you for the quality of your education".

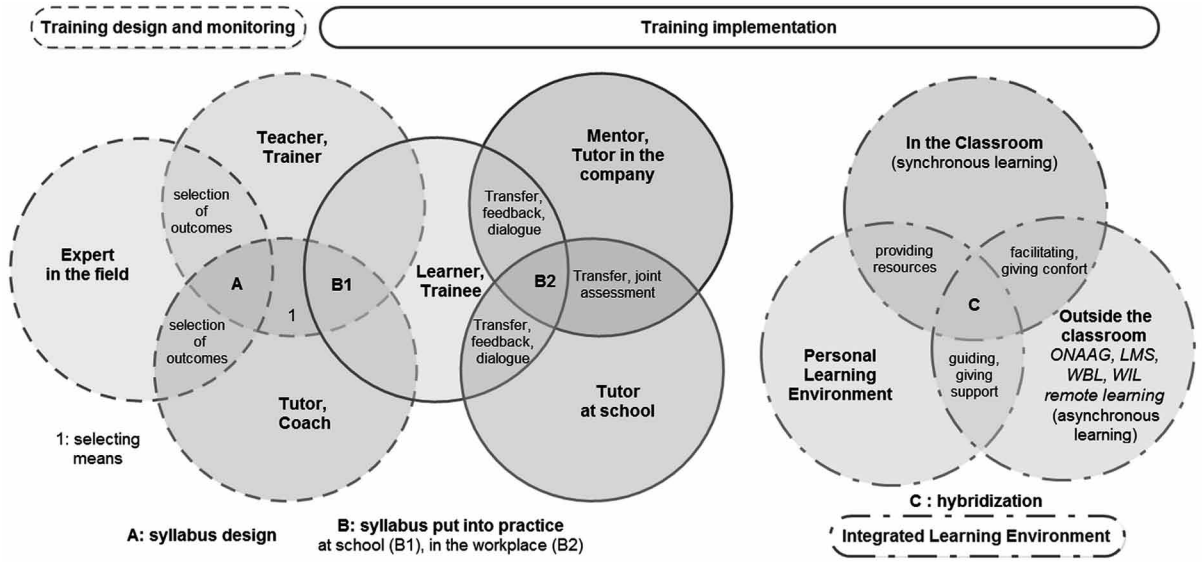
Integrated Learning Environment

Changing activity during lessons is a plus to maintain energy intake and attention. In that sense, autonomy of path in a given deadline but with sufficient delay helps the goal. ONAAG proves his contribution to maintain the link between the set teacher-trainers during alternation; it is a real asset for the course in the complex context of what we call Integrated Learning Environment (see in Figure 24 on the right) inspired by Pang (2010). Indeed, ONAAG requires generic ICT skills, urging the personal building of learning (personal work, learning organization and network) connected to PLE; building the Integrated Learning Environment (at school or in the company). The sustainable circles (on the left) show that the implementation of such means and the involvement of all actors in the course (design, monitoring and operation) give real opportunities for the interactions between actors (in and outside the classroom; B1 and B2); enhancing human capital and adding value to their individual and collective production. They are required to change behaviors. It enhances sustainable learning through formative designed experience in the classroom (serious game, ONAAG and Work Based Learning are some examples) or into the workplace requiring winning-trio: learner/tutor at school/Company mentor. The virtuous circles in Figure 24 stress the creation of a pedagogical team to jointly co-create syllabus and realization. At the scale of HE Providers, this complexity implies community of practices with internal and external collaboration for worldwide intelligence. This is the reason why we link the last three disks on the right through the learner.

Transferring ONAAG for Hybridized-Courses

The process of development tends to find human resources for production (ICT maintenance, Digital learning production support, Pedagogical team) or transfer (Learning community). Therefore, project is given value within consolidation of the co-creation and the opportunity of collaborative work, maybe leading to a new community of practice and deployment on other fields; first created with Laplace topic, the ONAAG-1 structure was transformed to Scilab topic and spread for 2 groups. ONAAG-2 could be modified simply by changing the example of the case study and functional part can be copied for new route with test-responses modifications. From the point of view

Figure 24. Integrated Learning Environment (C) with virtuous circles for actors (A, B1, B2)



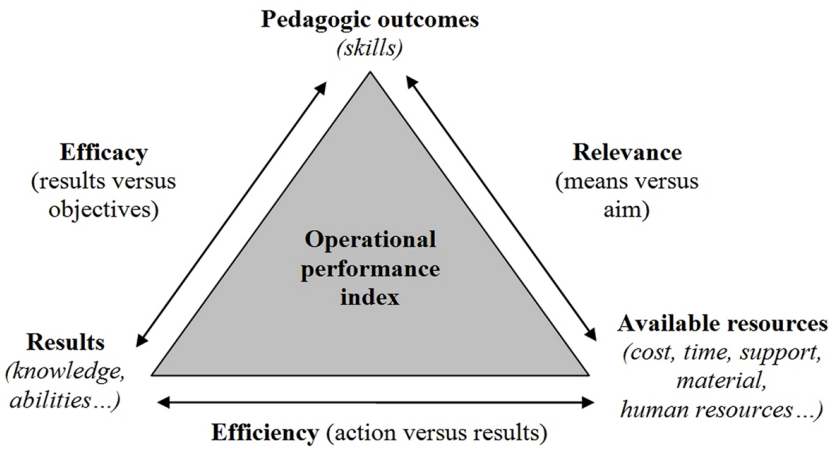
of management, ONAAG project is conducted with respect to sustainable development to comply customers' needs; they are the learners but also the teacher-tutor, the latter supporting ONAAG's development with respect to the mottos "Trainers first, Trainee second". It means that if teacher-tutor are considered as client, this new posture and considerations, will lead to the satisfaction of the clients; i.e. the trainees. Posture has changed to cope with complexity and initiate process to find funding, to animate, to develop and spread innovative or/and good practice through the education community. Today, ONAAG is transferred for a group enrolled in full-time training (see the third column in Figure 7); with integration of another colleague who already uses serious game and a joint LMS. Improvement relies in simplified tests for real autonomy as ONAAG is proposed as a free-access resource. ONAAG will be improved on the following aspects for future use: quality improvement of videos (technical) based on the developed scenario, higher robustness of the tests to validate each step during progression (better automation of transition steps for real autonomy, more specific guidance, more encouraging form of feedback in correlation with result), decrease of workload for teacher (simpler follow-up with only critical point to check and comfort) and help to better organization for the learner (giving larger deadline, enhanced explanation before the activity, develop tutorial about the reason-why of activity; compromise between self-progression in the learning and guided-support referred as *Guided Self-Learning*).

CONCLUSION

The idea of a fully integrated ICT solution to support the hybridized course was brought out. The aim was to adapt training due to time reduction and enhance better and easy follow-up of individual work during alternation. ONAAG was conducted respecting PDCA with monitoring indicators (operational performance index given in Figure 25 with sustainable compromises). Content selection and design took into account the "whole" knowledge of the learning process and environment. To fit the learner's and teacher's expectations, a value management process was

implemented in a leadership manner. Realization of the training is based on a DMAIC approach through ONAAG integration into the blended course. This complex solution, specific to the context, could be a good practice in order to perform efficient training within ICT. This point of view has also recently been translated by Tan et al. (2010) into a virtuous circle for hybrid course design and conduct (pedagogical rules, instructor roles, useful approaches and ICT) that resonates with value management, expertise and PLE; also stressing the involvement. Obviously ONAAG respects the outcomes. Note the complexity of evidence-based good practice to engage staff; ONAAG is a co-creation act initiated by the trainer for and with the trainees, developing each actor's complex PLE (skills, knowledge and autonomy). Actors have to change their framework (Johnson et al., 2014). To accomplish this transformation of Higher Education the following actions should be performed: first *to make teachers aware through training*; with respect to the educational dimension (understanding, taking into account, knowing models to design, teach and assess (Bloxham & Boyd, 2007); with hybridized-courses mixing different means having knowledge of assets and risks; with developing mentoring and coaching abilities; second *to guide students and learners to understand and accept their responsibility* with respect to their active attitude in their learning; their acceptance for mobile learning and re-building the learning environment (Biddix et al., 2014); third *to explain to managers of Higher Education* that teaching to a small homogeneous group of students is different from guided learning to huge heterogeneous population at any age; they have to be convinced of the efficiency of this way to conduct complex realization of trainings in a global worldwide environment. As a consequence, the workload of the teacher has to be re-defined to take into account asynchronous tasks in the job descriptions too; modifying the way to count working time, integrating the training of teachers too. Such modifications could not be performed without a real policy to support such changes due to what it implies to the organization of the HE Provider. Support can reduce the energy cost and facilitate interactions. That is why joint development making a "whole" of local experimentations helps faster transfer and better valorization in and outside the HE Provider. Based on Work Integrated Learning experiments, it is believed that a greater involvement of students in the training process (a more mature behavior considering their own choices in life) and an unwavering support of stakeholders would significantly improve the

Figure 25. Operational performance index to use in complex Higher Education



efficiency of teaching practices; leading to strong welfare at work for the innovative trainers, and a better well-being during training, at school and into the workplace for the students. The hybridization-based course presented, ONAAG, shows that the leader-teacher-tutor who conducts the training process with the group should develop his own transversal and intercultural skills (see Figures 1, 6 and 19). He is no long the one who masters the knowledge and provides it, but the one who guides others for a personal and autonomous construction of their knowledge. Upstream of the training, he is the expert that can identify the key points useful for the group in order to design the syllabus. During the realization, he mostly acts as a tutor who guides on a given set of learning routes proposed; explaining, reassuring and helping to revitalize the group or the individual. Downstream of the training, he might be a mentor; keeping contact due to the recognized experience. Such considerations comply with the complexity of the job of teacher-researchers at the university; mixing and interlacing knowledge in different fields and from several experiences will mobilize and create collective intelligence to create innovative solutions to global problems; benefitting from the collaborative community. As a consequence, teachers and trainers have to develop generic abilities that go beyond the mere scope of their inner competences; a global and complex perception of role is required. The learner is the connection to society (company, school) with the researcher-teacher-tutor; giving reality to the Integrated Learning Environment and consistent with complexity principles. Such innovation that integrates digital educational resources into a hybridized course requires support (fair and appropriate by HE Providers), transfer in the community and welfare at work.

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KEY TERMS AND DEFINITIONS

Compagnon: This French word (companion) stands for those historically trained through mentoring into the workplace; he creates a personal master piece (arts and talent) to prove his ability to his peers in order to become a recognized mentor.

Flipped Classroom: Is part of blended learning with asynchronous and synchronous activities. First, the students study topics. Secondly, in the classroom they apply the knowledge by solving problems during tutored activities; they learn by doing and by interactions with others. Several pedagogical means are used leading to a hybridization of courses.

Hybridization-Based Courses: Reference to a voluntary act mixing in an integrated manner ICT and traditional pedagogical methods to achieve a specific learning outcomes; knowledge, skills and transversal abilities (intercultural, collaborative); changing posture and creating PLE.

Natures of Results: Are Quality (customer satisfaction; specification and standard compliance and favorable working conditions), Profitability-Cost (increase of asset in the company; financial, technical, human, skills), Security (safety of goods, of people and information; minimal degree of vulnerability is always necessary) and Reactivity-Delay (relation of result with time and events).

ONAAG: Acronym of the innovative and learner-centered project *"Outil Numérique d'Appui de l'Auto-Formation Guidée*" (Digital Support for Guided Self-Learning); in order to facilitate knowledge acquisition and autonomy, stressing the interest of collaborative work in a secured environment. The project was supported by the University of Lille in the framework of the development of new pedagogy integrating ICT.

Trainee: Generic term for apprentice (IVT; younger than 26 years old with company contract), learner (CVT; older with a professional project supported by their company (employee)) and student (enrolled in initial full-time training); trainee suggests the act of learning (being trained; as opposed simply to being educated).

Chapter 5
New Literacies in the Intellectual Field of Education:
Mapping Theoretical Perspectives in Scientific Publications

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ABSTRACT

This article studies the theoretical perspectives about new literacies that are dominant in the intellectual field of education at an international scale. The baseline assumption is that this is the primary field in which discourses are produced and then recontextualised (selectively dislocated and relocated) as curricular contents in teacher education (Bernstein, 1993). Our identification of theoretical perspectives is based on the analysis of scientific publications in education from 2007 to 2010. The study combines the exploration of more than 1500 texts, 70 of which were analysed in depth. The main objective was to graphically represent the different perspectives, showing the relationships within and between each one of them, as well as the agents who produce and legitimatise them. The identified perspectives and the constructed dimensions of analysis have been used in further stages of research in order to study national and regional curricular documents. This chapter reflects on what these perspectives can contribute to the field of Engineering and Architecture Education.

INTRODUCTION

The need for including technology into education from kindergarten through college has been a persistent request for the last 20 years. These needs stem from structural economic, social and cultural changes that have shaped the nature of being and doing in contemporary society. From a historical point of view, technology inclusion in educational policies was related to the promise of improving education and solving teaching problems. However, proposals have not always been successful nor spurred significant changes in the way education is understood. Numerous authors

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have pointed out the limitations of these promises (Burbules & Callister, 2008; Cuban, 1986; Cuban, 2001 are among the best known) and they have historically shown how the introduction of each new technology triggers a new cycle of unfulfilled expectations (Buckingham, 2007). This type of reform assumes that intervention is progress: it is expected that a "new world" will emerge as a result of new programs, new technologies and new organizations (Popkewitz, 1991).

In this context, various international organizations (UNESCO, OAS, EU) have called for educational systems to develop new literacies that enable the formation of active and critical citizens in contemporary culture. Many voices demand a revision of the concept of literacy beyond the numbers and letters which were imperative for the survival of industrial society but not enough for the so-called information or knowledge society. Thus, the concept of literacy has been reconsidered and expanded in light of the social, cultural and economic conditions of the 21st century. Literacy is considered to be a skill for deciphering texts of various kinds, and for expressing thought; however, textual language is one modality among others. Today we incorporate multiple forms of images; music; body movement; social relations and all human expressions where thought and feeling are manifested as a part of life. Understood in this way, literacy can not be limited to text but must include "the skills to construct ideas in any of the forms that they are used culturally to create and express thought" (Eisner, 1991-1992:17). It is a question of literacy that includes digital aspects, but also exceeds them, as it involves the deeper meaning of contemporary culture and the conditions under which it is produced, to understand our place in the world we live in. Indeed, it implies a discourse where the educational practices required by contemporary culture gain meaning.

However, the study limits and perspectives of what is specifically called new literacies and how they translates into the education field is still blurred. Many authors from different fields of knowledge have made important contributions, but there is still no clear view of the perspectives adopted or the contributions made by basic disciplines to the field of new literacies. This chapter presents the results of the study of the theoretical perspectives about new literacies that are dominant in the intellectual field of education at an international scale. The baseline assumption is that this is the primary field in which discourses are produced and then recontextualised (selectively dislocated and relocated) as curricular contents in education (Bernstein, 1993).

The objective is to describe what each perspective considers as object of study, how they are named and defined, what methodologies are legitimate, who the representatives are, ultimately, what the boundaries are between what can be conceived and what can not, and who are the ones that can define it. These perspectives are produced by specific agents and agencies, which struggle to exercise power and control over the definition of pedagogical discourse. In this paper, we map and position each perspective showing the relationships in relation to the agents that produce and legitimate them.

This paper aims to clarify the field and thus provide indicators so it can be introduced into the curricular sphere of the different levels of education. In the university specifically, content needs that arise from cross sectional competencies present in all study plans curriculum and which are in some specific cases underdeveloped (Gewerc and others, 2010).

To do so, in the next section we review some specific antecedents that have been the basis for the design of this part of the study, and then we describe in detail the key decisions in the methodological process. The final sections present our findings and how them can contribute to the field of Engineering and Architecture Education.

BACKGROUND

The main conceptual orientation of this paper is based on studies by Bernstein (1993, 1999) and Bernstein & Diaz (1984) regarding the production of pedagogical discourse and the intellectual field of education. It is also based on further studies carried out by other authors (Czerniewicz, 2010; Maton, 2007; 2000; Stavrou, 2011; Moore & Maton, 2001) that deepen the analysis of specific intellectual fields and the ways knowledge is produced.

From the perspective of these authors, pedagogic discourse is seen as a principle for appropriating other discourses and relating them to the purpose of their transmission and acquisition, i.e. as a recontextualising principle. It is a principle that delocates a discourse from its practice and substantive context and repositions it according to its own selective principle of framing and classification. Therefore, Bernstein argues that "pedagogic discourse cannot be identified with any of the discourses it has recontextualised. In this sense, it has no discourse of its own, other than a recontextualising discourse". (B. B. Bernstein, 1990, p. 184)

Concepts of vertical discourse and horizontal discourse developed by Bernstein (1999; 1990) in relation to the modes of production and circulation of knowledge in intellectual fields allow a first characterization of the pedagogical field in general and the field of new literacies in particular. These concepts aim to describe the ways of knowing in a way that produces greater differentiation within and between these modes and explores the social basis of this differentiation. The distinction between the horizontal and vertical discourse is based on what Bernstein calls the form of knowledge. This notion does not simply refer to the way in which produced knowledge is ordered. As Moore and Maton (2001) indicate, the form of knowledge in an intellectual field is a principle that also regulates the manner in which new knowledge is produced. If this principle varies, the organization and, crucially, the mode of knowledge production within the field will change. In other words, any specific intellectual field is structured in a way that makes certain issues visible and others invisible in the current field of view.

The horizontal discourse is characterized by being organized in local segments linked to practice and specialized activities associated with what is usually called common sense knowledge. A vertical discourse, on the contrary, is characterized by strong distributive rules regarding access, transmission and evaluation of knowledge. The vertical discourse can take two forms: hierarchical knowledge structures or horizontal knowledge structures. Hierarchical knowledge structures build very general propositions and theories integrating the lower-level knowledge and, in this sense, they reveal the core unit underlining an extended range of apparently different phenomena. The form of knowledge in the social sciences and humanities could be characterized instead as a horizontal knowledge structure. These consist of a series of specialized languages with different modes of interrogation and criteria for the construction and circulation of knowledge. The set of languages that constitute any horizontal knowledge structure is not translatable to another, since each language has its own different assumptions and criteria to legitimize texts, its own acceptable 'evidence' and legitimate questions and problems. The speakers of each language become as specialized and selective as the language. The speakers' capital is linked to language and, therefore, the defence of their own language and confrontation with others are intrinsic to these knowledge structures.

In Bernstein's view, concepts of field and discourse are interrelated and interdependent. Fighting in a field with a horizontal knowledge structure is associated with the power to define legitimate forms of communication; the development of the field is given largely by the introduction of a new language rather than the integration of theories and existing approaches.

Some specific intellectual fields have been studied on the basis of these concepts. For example Maton (2000) analysed the field of cultural studies, Maton and Moore (2001) compared literary criticism and mathematics in relation to their knowledge structures. Elsewhere, Maton (2007) compared what he calls two cultures: the humanistic and the scientific. These authors extended the work of Bernstein by introducing the concept of epistemic device and structures based on knowledge and the knower (Moore & Maton, 2001).

Closer to our problem, the study of Czerniewicz (2010) describes the field of Educational Technology in Higher Education. The author distinguishes different specialized languages in Educational Technology ("Instructional Design", "Learning Technology", "Learning Science", "Computer Supported Collaborative Learning", etc...) and asks whether the existence of specialized languages means that they are immeasurable. In order to answer this question, she analyses the level of the specific empirical research problems in the field and inquires about the existence of a shared agenda in this regard. The author shows that there is a surprising agreement on the issues and objects of attention and lists some of them: issues associated with learning - particularly collaborative learning and informal or traditional learning - issues related to assessment and the role of teachers, issues related to inclusion, access and the digital divide, concerns about the institutionalization of education technology, and finally studies focused on the technologies themselves, which receive less interest. However, this degree of agreement in terms of specific problems is not maintained at the level of overall approach. At this level, the author describes two general theoretical perspectives that have the form of incommensurable languages.

The general description of the knowledge structure for social sciences and humanities provided by different authors provides a framework for approaching the field of study. The proliferation of terms in relation to the object of study is one of the clearest signs of language specialization in the field of "new literacies". Moreover, tracking certain terms and the dominance of some over others in a specific period of time shows the emergence of new languages that Bernstein describes as a mode of development for these structures.

In this sense, the study of the intellectual field of education has some peculiarities in relation to the analysis of other intellectual fields of knowledge production. This field produces intellectual discourse (therefore, it can be seen as a primary field), but the discourse produced and rules of its formation are recontextualising. This dual character requires specifying how we will use the concepts in the analysis and how to recover the results of studies in other intellectual fields. We said that the field of education characterized its discourse is a recontextualising principle. This quality has some important implications for our analysis, which we would like to highlight.

Firstly, a recontextualising nature can be attributed not only to discourses but also to the agents and agencies of a field. In other intellectual fields, the agents of knowledge production generally are not the same (and are even isolated from) the agents of recontextualisation and reproduction. However, in the field of education, those who produce new knowledge often also recontextualize it. It is not unusual for a single agent to be a researcher at the university and a technical advisor in a state agency charged with designing curricular documents. For this reason, it is important to formulate questions about the way in which the positions of actors shape the problems they investigate and the modes in which they communicate research results (in terms of rhetorical assumptions and audiences).

Secondly, we have chosen to study the discourses of the intellectual field of education through articles published in scientific journals. Journals account for the ways in which knowledge is evaluated, distributed and validated in a particular field and are a means by which products and producers of knowledge are legitimized. In addition, the quantity, quality and degree of dissemination

and recognition of journals express the relative power of different academic communities and their degree of national and international influence.

In the textual study, we want to emphasize the relationship between texts and discourses and the notion of intertextuality. We have analysed the texts in order to identify perspectives and we have complemented this by examining the citation and co-authorship relationships. The central assumption is that a text is always constructed in relation to others and that these relationships are present more or less explicitly. Opposition relationships can be more explicit in horizontal knowledge structures in order to differentiate and legitimate objects of study and specific practices through the use of a new language. Bernstein (1993) proposed that intertextual and intratextual relationships vary from production field to recontextualisation field. The recontextualisation field transforms intertextuality into intratextuality, i.e. in the field of discourse production a text must be original. It rejects intertextuality and proclaims exclusive authorship (Bernstein, 1990).

What characteristics do the studied texts have with respect to intertextuality? They are texts from an intellectual field, which, as we have pointed out, is inherently a recontextualising field, thus, it is possible not to deny intertextuality. To the contrary, it might appear as a legitimation strategy. Texts from the intellectual field of education do not claim to be original texts, and in this sense they share certain features with recontextualised texts.

METHODOLOGY

From a methodological point of view, this study has an interpretative approach, which eclectically combines techniques that allowed us to explore publications both in depth and extensively. Our identification of theoretical perspectives is based on the analysis of scientific publications in education from 2007 to 2010. The study combines the exploration of more than 1500 texts, 70 of which were analysed in depth. The main objective was to graphically represent the different perspectives, showing the relationships within and between each of them, as well as the agents who produce and legitimatise them. The distinction between perspectives takes into account what each considers its object of study, the terms used to define it, and the construction knowledge procedures it considers to be valid.

We used methodological tools from social cartography (Gorostiaga, 2009; Paulston, 1996) to identify and characterise each perspective's arguments and the relationships between them. Critical texts analysis (Fairclough, 2003, 2010) constituted the main tool for identifying perspectives.

We created a database containing publication details: title, authors, institution, country, date, and cited texts. We considered cited texts to be those that were connected to the main arguments held by the author. The database includes 1557 texts and 1779 authors.

We decided to analyse journals instead of books. Journals are published on a regular basis, and the time between intellectual production and peer dissemination is shorter.

The iterative process for identifying and characterizing perspectives was based on social cartography as proposed by Gorostiaga (2009). We made some adjustments related to the construction and use of a database for organizing the analysis. It is possible to reformulate the steps proposed by Gorostiaga in the following stages (not necessarily sequential):

1. Texts were read paying particular attention to arguments about literacy and how digital technologies were considered. From the first reading we developed the initial analysis categories. At this stage we worked with 10 selected texts from reviews conducted by other authors (Bawden, 2002; Gutierrez Martín, 2003; Colin Lankshear & Knobel, 2008).

2. We selected articles published in internationally recognized journals in the field of education and educational technology and media education in English and Spanish. We included the issues published between 2007 and 2010. At this stage we included 70 articles, from ten journals and handbooks on the topic. From the general journals we selected articles concerning educational technology and media education, new literacies and digital literacy. We conducted a thematic search by keywords and went through all issues of journals. From the specialised journals, only those articles that correspond to the following criteria were selected: 1) Teacher education and ICT / educational technology / new technologies / new literacies / digital literacy, or 2) digital literacy / new literacies / media literacy / audiovisual literacy / even if not strictly referring to teacher training.
3. The reading of new texts allowed us to construct dimensions of analysis and to identify representative arguments and categories within these dimensions. These dimensions were checked with reviews conducted by other authors and the categories proposed by them. Based on this comparison we built the list of categories presented in the next section.
4. We loaded each text onto a database that detailed publication title, author, institutional affiliation, country, year of publication and texts that quote. We considered 'cited texts' to be those in the article referring to theoretical basis or background for the study, i.e. those in which the quoted text was connected to the central arguments. The goal was to have information that would make it possible to explore intertextual relations described in the previous section. These data formed the basis of 1779 authors and 1557 texts.
5. Each text was tagged according to its degree of agreement with the arguments and dimensions identified in step 3. We also included as labels those produced by the review authors in order to compare our approach with recognized experts in the field.
6. We constructed graphical representations of different perspectives and compared them to each other (derived from both processes of reading and representation of the quote and authorship relationships). The conclusions in this chapter are based on these representations.

On this basis and during the process of analysing the selected articles, we constructed the analysis dimensions and categories that follow. These categories are proposed as an spectrum: i.e. the categories within each dimension arguments are presented as poles in which texts can be placed according to their degree of support or disagreement. In cases where it was not possible to group them into a single argument without the loss of too much information, we constructed open categories and recorded the diversity of options.

These binary options allowed us to display the text contents, because, as we have said, most define their concepts as opposed to others. In many texts this opposition is explicit and a term is presented as superior to its opposite. Furthermore, this binary construct is presented as a feature of horizontal knowledge structures: their tendency to build dichotomies.

Table 1 presents dimensions, categories and main arguments of each pole.

Table 1. Analytic dimensions and categories

Dimensions	Categories	Arguments
Literacy	State Literacy is seen as a state rather than a process. Literacy is a set of skills, abilities, etc. The skills do not differ from one type of text to another or from one practice to another. Unique simple definition of literacy.	Process The construction of meaning is the central feature of the literacy process. Literacy is a diverse and multiple processes. The practice of reading / writing varies widely in different types of texts.
	INDIVIDUAL Literacy is an individual cognitive achievement.	SOCIAL Literacy is an interactive, collaborative activity, embedded in social purposes even when a person is reading in solitary.
	RATIONAL Emphasis on the intellectual processes.	HOLISTIC Emphasis on recreational, emotional, physical aspects.
	INFORMAL – EVERYDAY ACTIVITY The process of literacy is a natural result of growing up in a literate society easily acquired without explicit instruction. Focus on home and community.	TAUGHT – SCHOOL CENTRED Education is the key in the literacy process.
Purposes	FUNCTIONAL - JOB ORIENTED Employability and competitiveness in the labor market are main concerns. Simplified tasks related to participation in the labor market.	TRANSFORMATIVE CULTURAL CITIZENSHIP Critical appreciation, cultural participation, resistance are main concerns. Literacy is a factor of social identity, empowerment and resource for rebuilding itself, it enables transformation of practices, rules and relationships of constituted culture.
	TRANSMISSION Emphasis on public responsibility for the transmission of values and knowledge necessary for social inclusion as a citizen. Concern about the school and its role in these processes of transmission	PERSONALISATION Emphasis on the development of identities and possibilities for individual expression.
Technological foci	INFORMATION Emphasis on technology as a tool for information processing: Telecommunications, Computer Science, Information Systems	COMMUNICATION Emphasis on media: Audiovisual, press, mass media.
	TOOLS Direct relationship between means and ends. The tools have a predetermined purpose and are used by people	CULTURAL ARTIFACTS Emphasis on the relationship between culture and technologies. Use of technology transforms people and technologies are also changed in the process.
	CONSUMPTION Emphasis on use and analysis. In the case of selection information: search; processing information. For media: critical reading, reception, etc…	PRODUCTION Focus on agents as producers of culture. Categories: participation, creation, production, remix.
Research foci	IMPACT ON SCHOOL LEARNING Impact of technology on learning and literacy outcomes. Comparative studies on learning achievement using and not using technology. International comparisons in relation to the achievement of certain skills.	
	YOUTH PRACTICES Inquiries regarding identity and youth practices with new media.	
	INTEGRATION/ADOPTION OF TECHNOLOGIES IN SCHOOL SETTINGS Factors influencing the adoption of technologies in schools. Studies on the personal adoption of technologies by teachers.	
	DIGITAL DIVIDE Relations between access and use of technologies and social equity. Comparisons between different countries regarding access to education. “Access Levels”. Comparisons regarding school achievement linked to access out of school or social origin.	

continued on following page

Table 1. Continued

Dimensions	Categories	Arguments
Methodology	QUANTITATIVE Studies that include one or more techniques/ methods like surveys with sampling design, experimental and quasi-experimental design.	QUALITATIVE Ethnographic orientation designed to explore the cultural environment surrounding the use of technology through interviews, observations, journals, discourse analysis and text
Definition of learning	BEHAVIOURAL Reality is external and objective. Knowledge is acquired through experience. Instruction focuses on the manipulation of environmental factors to influence the behaviour of students.	
	Cognitive The reality is mediated and knowledge is obtained through experience and thought. Teaching focuses on helping students to develop symbolic mental constructs in which knowledge and skills are based.	
	Constructivist The reality is internal, and knowledge is built. Teaching focuses on helping students to actively find personal meaning of the experience.	
Disciplinary origins		
Knowledge included in "new literacies"		

MAPPING MAIN THEORETICAL PERSPECTIVES IN NEW LITERACIES

Texts and Producers: Analysis of Citation and Co-Authorship Relationships

Relations between Perspectives

The initial analysis of the texts included in our database allowed us to identify the most widely cited articles and authors. 162 authors out of 1779 have three or more citations by others within the database (self citations are excluded).

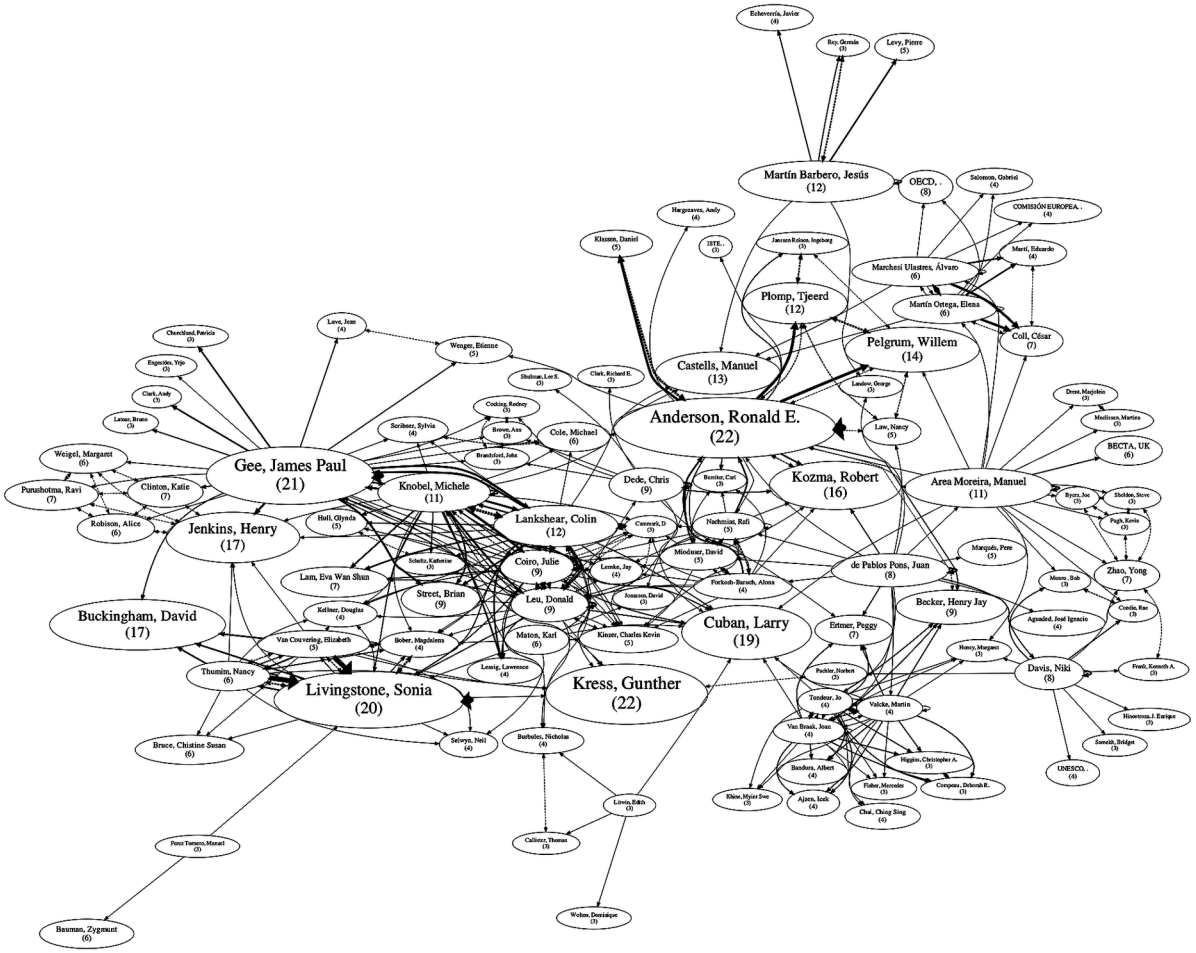
The representation of citation and co-authorship relationships among these 162 authors are shown in Figure 1.

The solid lines represent quotes from one author to another, the dashed lines show co-authorship relationships in the database. This representation only incorporates authors who, besides having three or more citations, are referred by one of the "most cited" authors. For clarity of representation, the graph does not show those authors without any links inside the graph. In addition, we correlated the size of the oval representing the author with their number of citations and the thickness of the line with the number of times that an author quotes another.

The diagram enables us to identify nuclei around certain authors (Anderson, Gee, Buckingham, Livingstone, primarily) and others orbiting around them. It is possible to say that these nuclei graphically show the perspectives described in the section above. For example, it is difficult to find authors from different nuclei related to each other and the references between authors from different perspectives are scarce.

It can be said that the graph is characterized by dispersion. No authors have more than 22 total citations in the database. Nor is it possible to identify key texts. The text with most citations has been referenced only six times. These features are consistent with the idea of horizontal knowledge structure proposed by Bernstein (1999) and

Figure 1. Citation and co-authorship relationships between authors with 3 or more citations in the database



the existence of incommensurable specialized languages (Bernstein, 1999; Czerniewicz, 2010).

On the left side of the graph we can see the authors included in the first two perspectives (New Literacies and Education in new media). In the central section, around Anderson we find the authors related to the use of technology in learning perspective. The authors from the digital divide perspective appear marginally with few citations each and they do not seem to make up a core.

Another aspect that this representation allows us to highlight is the pre-eminence of English-speaking authors. The Hispanic authors are marginally located, citing texts in English but not being cited. Moreover, they do not appear to constitute a node in the network, on the contrary they are linked to one or more of the aforementioned centres.

This issue is not unique to the literature on this subject. Palamidessi and Devetac (2007) found that most of the production in journals on education is in English and is concentrated in the US (90% of journals published in that language). There, along with general education publications, there is a huge number of journals on different subjects area (curriculum, history of education, comparative education, higher education, special education, sociology of education, educational psychology, etc...). Insofar as the Spanish-speaking world in the early twenty-first century, the number

of journals devoted to education does not reach five hundred, and, unlike their English-language counterparts, most of them have a general profile.

Quantitative analysis of the texts included in the database shows that by home country, most of the authors with 3 or more citations were from the United States (almost 40%), followed by the United Kingdom with almost 20% and Spain with 10%. The remaining countries do not exceed 5%.

From the analysis of the institutional affiliation of the most cited authors it is possible to elaborate a list of the strongest research centres in the period studied. In the UK, there is a remarkable presence of the Institute of Education, University of London and London School of Economics and Political Science. While in the United States, the Massachusetts Institute of Technology, the University of Wisconsin-Madison and Stanford are at the top of the list. In Spain, the distribution appears to be more uniform, although the low number of citations could be distorting the data.

Relationships within Each Perspective

The following description is focused on the identification and description of the perspectives on new literacies. We present a tentative interpretation of the multiplicity of positions and arguments that we found.

We have tried to describe the different perspectives on their own terms, however, we recognize that analysts may be subjective and that texts are always open to multiple interpretations. We speak of dominant perspectives because the analysis derives from the study of articles in journals with an international presence, taking into account that the dominant criteria of one specific intellectual field are displayed in the process of evaluation of articles in an indexed journal. The texts have been grouped according to the salient arguments and similarities have been prioritized over the differences.

Through qualitative analysis of the texts we identified four main perspectives that we call: new literacies, new media education, use of technology in learning and teaching, and digital divide. The justification for grouping texts into these perspectives relates to the dimensions and categories described in the previous section: definition of literacy, focus in relation to technology, purposes for including new knowledge in school, definition of learning, research topics and methodology that are prioritized and disciplinary origin.

While the central arguments of each perspective emerge from the analysis of all the texts, we selected one "representative" text from each perspective. The term representative did not arise in statistical terms but in the way the arguments are present in the texts. There are texts that best encapsulate the arguments from each perspective. We chose fragments from these texts to show characteristic arguments and how they were identified during the process of analysis. Then we studied who might be representative of each perspective in terms of number of citations and co-authorship relationships.

In order to explore the relationships within each perspective group, we choose a display mode that presents the database from the perspective of the selected text. To do this, at the first level we take the authors cited in the text and then, at the second level, the authors cited by those who were at the first level. We kept the representation criteria (colors and line weights, size ovals according to the amount of the total citations) for a map from the perspective of a specific text.

The representations generated allow us to appreciate the citation relationships inside each perspective and to focus on the nuclei shown in Figure 1.

The "New Literacies" Perspective

This approach is characterized by defining literacy as a process in which the construction of meaning is central. It is a multiple process, which varies significantly from one context to another. This approach proposes that practices associated with

reading and writing are fundamentally social activities with a central component of interactivity and collaboration. Emotional and recreational aspects play an important role in the processes of literacy, their study is not restricted to the investigation of intellectual aspects. Importantly, literacy processes are seen as a result of growing up in a literate society, that is, teaching and schooling are not that relevant to access to these competences.

In connection with the purposes of including new knowledge in teacher education (and education in general), this perspective tends to emphasize lifelong learning, cultural expression and personal fulfilment. They argue that these literacies contribute to the development of critical and expressive skills allowing for a full life and the building of informed, creative and ethical societies. Regarding the focus on technology, this perspective emphasizes the relationship between culture and technology and integrates research that studies the social construction of technologies from a historical and anthropological point of view. Most of the texts included here study digital practices arising from the convergence of computing and communications technologies.

The focus of research is mainly linked to the study of the practices of interpretation and production of messages in different environments, particularly youth practices. Research is usually focused on outside of school practices or types of activities that are not usually valued by the school. Thus, issues related to the processes of identity construction and ethical issues regarding online practices are included. Video games, fan communities, different types of remix appear as privileged areas of study. Probably because many of the authors are from the field of linguistics, there are several studies that focus on processes of appropriation of a second language in immigrant population and issues related to multiculturalism.

The methodological approach is qualitative, mainly involving ethnographic studies that explore online practices through interviews, observations, diaries and text analysis. From the point of view of learning, this view may be described generally as constructivist. Particularly, it is linked to constructivist theories that emphasize the social aspects of learning such as situated learning (Lave & Wenger, 1993).

An example of this approach can be found in texts identifying themselves as coming from the New Literacies Studies (Coiro, 2008; Gee, 2009a, 2009b; Lankshear & Knobel, 2008). This line of work is in the tradition of New Literacy Studies (Street, 1993) expanding their field of study into digital environments and new modes of reading and writing.

As a representative paper, we selected a study by Lankshear and Knobel (2004) about reading and writing texts in the eBay community. One issue that stands out in this paper is that the authors present themselves with their eBay user names (netgrrrl and chicoboy26) and clarify in a note: "chicoboy and netgrrrl are eBay users. In physical space they are known as Michele Knobel and Colin Lankshear. " This almost anecdotal note shows that these scholars are not only part of the community they are studying, but also consider it important to show that they are. This is a common feature in this research perspective, many authors present themselves as gamers or members of different communities of fans. In the introduction of the text is expressed:

This chapter focuses on the emergence of a new practice of literacy: a system of ratings and reviews by the community that logs on to eBay, which is a new way of reading and writing about aspects of the world that are important for eBay users, also called eBayers.

The authors discuss "new literacy practices". The expression "literacies" in this case is from the United States to define " socially recognized ways of generating, communicating, and negotiating significant contents by means of codified texts in Discourse participation contexts (or as members of Discourses)". They clarify, "What we wish to say in a recognized manner can be understood in relation to the concept of practice

"(C. Lankshear & Knobel, 2008). And they refer back to Scribner & Cole (1981) to propose that " A practice, then, is made up of three components: technology, knowledge and skills"(C. Lankshear & Knobel, 2008, p. 75)[1].

Therefore, literacies are not defined as skills or acquired states but as practices. In the excerpt it is possible to note the emphasis on the social aspect of technology (they are part of a practice) and the importance assigned to the processes of construction and negotiation of meaning in the definition of literacy. It also explicitly affiliates itself to the so-called New Literacy Studies of which Scribner and Cole are important exponents.

Regarding methodology, this research is based on an analysis of the content in ratings and reviews produced by internet users and email interviews. The analysis seeks to interpret the behaviour of actors in this community and to understand how the ranking system shapes these behaviours. It is an anthropological analysis of an online community. Taking excerpts from the conclusions we note that the concern focuses on understanding how the rules are constructed in this community and how these rules shape the user practices:

EBay deploys strategies to define what constitutes good practice in the field of trade in cyberspace. They have introduced the community rating and review systems as part of their overall strategy. This is intended to serve as part of a "delimiter order" as a discursive order (currently in the process of being established) that will limit participants to act in certain ways and not others. (...)What we think is apparent in the fragments of data presented above are various "ways" of using the ratings game by consumers. In the system produced for them, consumers are "insinuating" ways of "inhabiting" which they are familiar with, which they adhere to or which are otherwise satisfactory or empowering to them, no matter how unpleasant some of them may seem. Digital literacies of ratings and reviews can best be understood as endlessly complex and multiple. (Knobel & Lankshear, 2004, p. 45)[2]

Several points can be identified in this fragment. First, the analysis is performed by extrapolating De Certeau's distinction (1999) between producers and consumers in order to expand the focus from "consumption devices" to "a broader understanding of social practices" (Knobel & Lankshear, 2004, p. 45). There is no reference here to the technology but to social practices. The focus is on understanding how the rating system influences the formation of personal identity and configures the relationships between people in this space. The conclusion about the various ways of inhabiting this space reinforces the idea of multiplicity and diversity in relation to literacy.

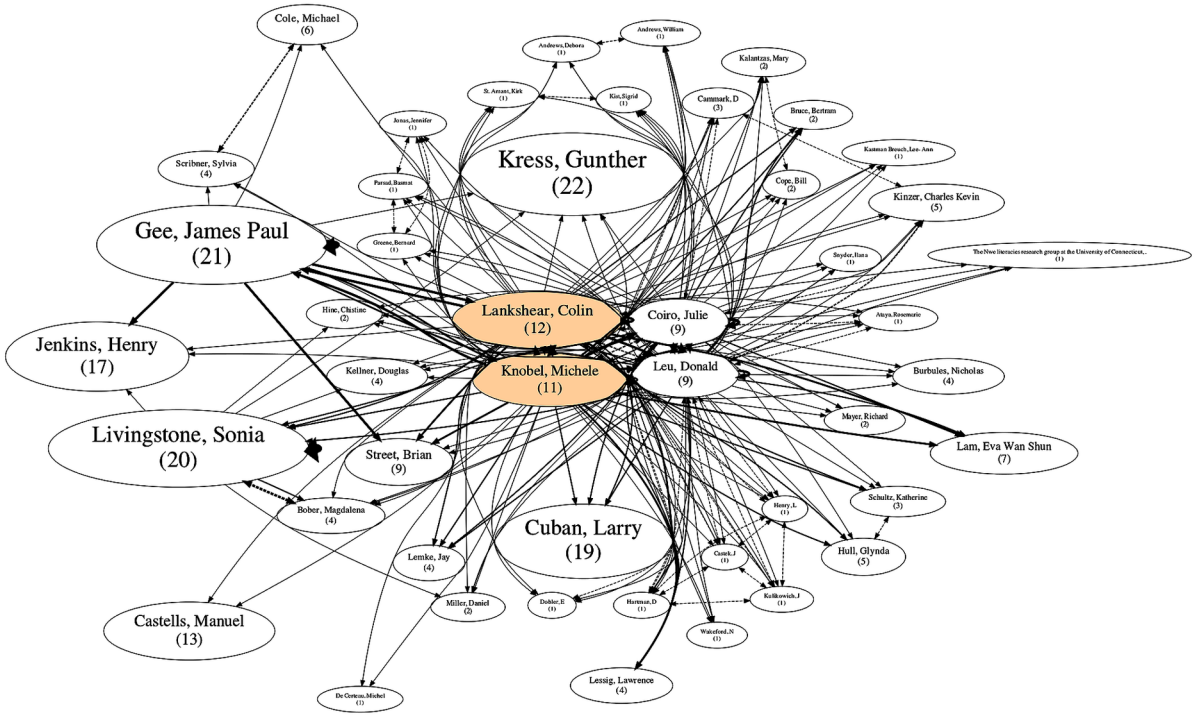
Finally, although the text raises questions about the relationship between this community and the school, the focus is on studying informal areas and the way in which subjects are linked to them. In a schematic representation involving the dimensions and categories that we have built, this perspective can be described by the presence of the arguments shown in Table 2.

Figure 2 shows strong citation relationships with James Paul Gee, who seems to be a benchmark for this approach. The presence on the graph

Table 2. Central arguments of the new literacies perspective

Dimensions	Categories and Arguments
Definition of literacy	Process
	Social
	Integral
	Natural- everyday
Purposes of literacy	Transformative cultural citizenship
	Personalization
Technology Focus	Information – communication convergence
	Cultural Artifacts
	Production
Research Focus	Youth practices
methodological orientation	Qualitative
Definition of learning	Social constructivist

Figure 2. Chart of citation and co-authorship relationships with respect to the text by Lankshear



of authors associated with linguistics, New Literacy Studies (Brian Street, Michael Cole, Sylvia Scribner) and situated learning theories (Lave & Wenger) again highlights the relationships that we have noted.

Moreover, it also reveals strong relationships with authors from the perspective we call education in new media. While there are no co-authorship relationships, other citation relations (weaker than the relationships within this perspective). Repeated references to Manuel Castells and Larry Cuban in different graphs might be addressing some studies as "must be referenced", although the number of citations diminishes the importance of this interpretation.

Regarding the institutional affiliation of the authors, we found greater presence of US and Australia in the graph.

The Perspective of New Media Education

This approach shares many of the arguments with the one described above, mainly the way they understand literacy and technology. We found a greater emphasis on communication and media as a field of study, in contrast to the idea of technology. In addition, the papers we group here give more importance to schools and critical training on the processes of interpretation and production of media messages. In this sense, political participation tends to appear more strongly in the areas shaped by new media as purpose education for education.

The texts that best represent the arguments of this perspective are those from media education in the UK (Buckingham, 2005, 2007); and so-called New Media Literacies Studies in the United States (Jenkins, 2009).

The text that we chose as an example of this perspective is Burn (2008) published in the Handbook of Research on New Literacies. This text presents the results of a joint investigation with David Buckingham and Caroline Pelletier. This project studied the processes of producing a video game by adolescents who used a software authoring tool.

We chose this text as an example because it is quite explicit about its theoretical affiliations and methodological decisions. The author suggests connecting the semiotic analysis of media texts –based for example on the work by Kress and Van Leeuwen (Kress & Van Leeuwen, 2001; Kress, 1998) - with research on the cultures of those who produce and receive these texts, taking as background the cultural studies in general and the research by D. Buckingham and J. Sefton Green ((Buckingham, 2002; Sefton Green, 2009). This is an example of qualitative research that complements the analysis of multimodal texts (with the aim of contributing to the construction of a multimodal semiotics) using in-depth interviews with the producer of the text.

We take an excerpt showing similarities with the previous perspective on how technology is understood (in this case as means) and processes of producing and interpreting meaning:

It relates this tradition to a theory of textual analysis rooted in the cultural and social function of the text, derived from sociolinguistics, and Halliday (1985), in particular. As a necessary corollary of this, it connects textual meaning with the social interest of its related sign makers - those who make it, and those who use, read, view, or play it. In the context of education, it offers a theory of signification ready for synthesis with the work of scholars of children's media cultures, in particular Buckingham (1996, 2003; Buckingham & Sefton Green, 1994), who provided influential research on how children engage with media texts, as well as proposals for how the pedagogies in media education might be influenced by cultural studies. (Burn, 2008, p. 152)

The cited passage again leans towards social aspects as well as the necessary link between textual analysis and the study of social discourses: "The formal structures of semiotic analysis need to be constantly connected to the discursive and cultural ocean in which the producer of signs swims: in this case, the discourses of games, players and popular media "(Burn, 2008, p. 177). In turn, this text presents a greater interest in the semiotic analysis of media and multimodal texts. This emphasis is related to the origin of the research, most strongly linked to communication sciences and cultural media studies. While the selected text is not explicit regarding the role of schools and the social purposes of literacy, we can take paper by Buckingham (2008) as a reference to complement the analysis. There, the author proposes:

Ultimately, media education implies a rethinking of the notion of literacy, which remains central to the social purpose and mission of the school (…) It seems extraordinary that the school system should continue to ignore the dominant forms of culture and communication of the last century, let alone those that are now emerging. A change is long overdue: media literacy – including digital media literacy- should be seen as a core curriculum entitlement for all children. (Buckingham, 2007, p. 180)

Because the above studies stem from a tradition rooted in educational practice, interest in school education is higher and concern for the formal inclusion of media contents in the compulsory curriculum is explicit. This feature distinguishes papers in this perspective from those in the first one we described. Another unique feature is the importance attached to emotions, often relating to

the study of the relationship between cinema and education or images and pedagogy. An example of this may be another paper by the same author (Burn, 2010) on the emotions provoked by horror films in young people and the implications for media literacy.

A summary of the arguments shows the points of confluence with the perspective described in the previous section (see Table 3).

The representation of the text by Burn (2008) can be seen in Figure 3.

This graph highlights some issues that were less visible on the overall map. On the one hand, it shows the citation relationships between the perspective called "new literacies" and "new media education", which would account for shared approaches and recognition by authors from different traditions. Note that these authors (Colin Lankshear, Michele Knobel, Julie Coiro, Donald Leu) have an indirect presence in the graph through citation relationships with James Paul Gee.

In turn, the co-authorship relationships indicate closer links between academics belonging to the same research group or university. Here we can see that the Institute of Education, London University as an important space, to which central exponents of perspective, David Buckingham and Gunther Kress, belong. The presence of strong citation relationships with Sonia Livingstone could reflect the importance of this author and the London School of Economics and Political Science as an institution linked to the first group.

Finally, references to the texts by Raymond Williams, Roland Barthes, Mikhail Bakhtin, Pierre Bourdieu and Lev Vygotsky reflect a socio-cultural approach at the theoretical roots of this perspective.

Table 3. Central arguments of Media Education perspective

Dimensions	Categories and Arguments
Definition of Literacy	Process
	Social
	Integral
	Natural- everyday
Purposes of literacy	Transformative cultural citizenship
	Transmission and customization
Technological Focus	Information – communication Convergence (greater emphasis on communication)
	Cultural Artifacts
	Production
Research focus	Youth practices
Methodological orientation	Qualitative
Conception of learning	Social constructivist

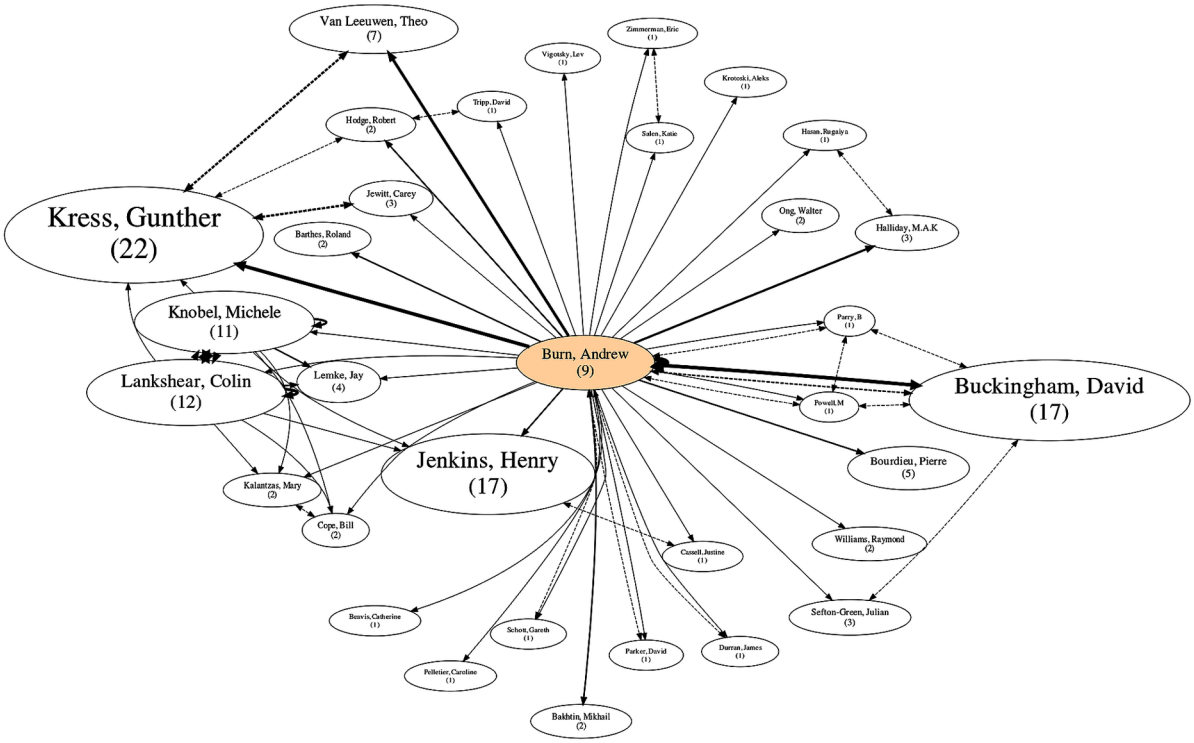
The Use of Technology in Learning and Teaching Perspective

Most of the texts included in the reference approach are primarily concerned with the use of technology by students as a means of enhancing learning. From the perspective we call the use of technology, computers and the internet are mainly seen as new forms of educational media, educational technology or learning systems.

In texts grouped under this category, new literacies do not appear as a central theme. When referring in some way to the definition of literacy, these texts speak of "competencies in information technology", "digital competencies", "digital literacy", or "literacy in information technology." These new types of knowledge are generally characterized as a set of skills that an individual possesses or lacks. These skills are defined in a relatively generic way regardless of the context and those related to intellectual processes are emphasized.

In this perspective, schools occupy a central place in the teaching of these skills and purposes of this transmission focus on preparing citizens for adequate participation in the information and/or knowledge society. Society is described as increasingly based on information, often in a complex and mediated manner. In this society, literate individuals are more likely to achieve a higher

Figure 3. Citation and co-authorship relationships with respect to the text by Burn, A. (2008). The case of Rebellion: Researching multimodal texts.



level in the job market, and literate societies are more likely to be competitive in economic terms.

The technological focus, therefore, centers on information and digital technologies are seen as tools for information management.

Research topics can be grouped into two main areas. On one hand, some texts analyse the impact of different technologies on learning by assessing learning outcomes in the presence or absence of certain technologies. Other texts study the incorporation of technology into teaching and education systems, as well as the factors that influence the adoption of technology by teachers and institutions, primarily from an evaluative perspective.

Seeing as the main focus is the achievement of measurable outcomes and practices, the predominant quantitative methodological orientation is quantitative, primarily consisting of large-scale statistical studies including general surveys of teachers, students and administrators as well as experimental and quasi-experimental studies.

Representative texts from this perspective are mainly produced by authors from American and European universities. The research is often done in collaboration or is funded by governments and international organizations. One possible example is the text by Anderson (2008), which presents the implications of the demands by the global knowledge economy in terms of skills and learning strategies required from youths.

The terms "information society" and "knowledge society" appear frequently in texts from this perspective. The text we analyze proposes a distinction between these two terms based on the distinction between information and knowledge: information refers to intentionally structured data while knowledge refers to the cognitive states needed to interpret and process the information.

The knowledge society is presented as a result of two main forces: the increased level of cultural interaction made possible by global electronic networks and an economic system where knowledge functions as merchandise.

The text by Anderson attempts to express the demands made by the knowledge society in terms of skills required of students and the learning strategies they should develop. In this sense, it can be interpreted as part of what Fairclough calls "neoliberal discourse of economic change that presents the process of 'globalization' as a fact that requires 'adjustments' and reforms with the aim of improving 'the efficiency and adaptability' necessary to compete ... " (Fairclough, 2010, p. 100). The demands have to do with the increasing amount of information, the lack of organization and evaluation, rapid change and so on. In this sense, we can say that the emphasis is still on technologies for managing information (and not on communication) and the skills required for work. However, the skills required for the work include communication skills related to teamwork.

The author describes an emerging paradigm called "Emerging Pedagogical Practices Paradigm (EPPP)". We refer back to the paragraph describing the paradigm, because it summarizes some of the characteristic features of perspective:

This paradigm emerges mainly from three intellectual traditions: 1) Continuous learning, emphasizing the need for learning and independent learning; 2) constructivism, emphasizing collaborative learning, real-world projects, real achievement and student responsibility for learning, and 3) digital literacy, especially the search and analysis of information. The EPPP emphasizes many requirements of the knowledge society, but has yet to explain the full range of required competencies related to knowledge of ICT. Essential skills such as critical thinking, deep understanding and high performance learning are yet to be integrated into paradigm (Anderson, 2008).

Two aspects reappear at this point: the first is the importance given to continuous learning, which can be interpreted from the cultural thesis of the lifelong learner (Popkewitz, 2009), and the second is the importance given to information management. This perspective gives a central value to technologies in the development of learning throughout life. In the words of Popkewitz (2009):

Computer learning, for many, is today's philosopher's stone. Maeroff (2003) argues, for example, that on line processes will unlock the unfulfilled promise of the new cosmopolitan world citizen that the Enlightenment philosophers could only have wished for. (…) On line learning is treated as revolutionary (the tittle of Maeroff's first chapter); that revolution is where technology makes possible the individualization of learning. (Popkewitz, 2008, p. 117)

Both can be interpreted in relation to the purposes of literacy, which in this case would be subordinated to the need for responding to the demands of the knowledge economy by promoting the skills required for the changing world of work.

Moreover, the effort to break down these skills into a series of competencies reveals a view of literacy as a state that can be taught and assessed. What is proposed is a "taxonomy of skills based on knowledge that reflects priorities of the knowledge society, especially those that apply to the changing nature of the majority of the jobs. This is intended to guide curriculum design, learning activities and assessment, particularly when students have access to ICT tools." (Anderson, 2008, p. 13).

As we can see in this text, the skills considered necessary for work have a relatively broad conception in relation to literacy: they include working with multimodal texts, communication skills and other complex thinking processes. However, this perspective also includes more restricted definitions of literacy that are reduced to the domain of certain software packages or specific skills. As an example we can take the following excerpt defined areas of teacher competency. Within the technical area the follows is specified:

... If we delve a little deeper into the analysis of the technical expertise area, we could say along the lines of several authors (BECTA, 2007; Cabrero, n.d.; Ministerio de Educación, 2006) that it includes the management of basic concepts and functions associated with ICT and the use of personal computers, the use of productivity tools (word processing, spreadsheet, presentation software) to generate various types of documents, the management of concepts involving, of course, the use of Internet tools, web resources and synchronous and asynchronous communication for the purpose of accessing and disseminating information and establishing remote communications. (Prendes Espinosa & Castañeda Quintero, 2010, p. 173)[3]

In the argument sustained by this text, it is possible to identify a set of skills which are primarily intended for operational management of productivity tools. In this perspective We also included a series papers works that do not link the integration of ICT to the demands of the knowledge society, but that assign this integration a positive value in itself. This research measures the use of certain technologies in schools, the barriers to ICT integration, as well as the perceptions of teachers regarding ICT integration, and assumes that this inclusion has the effect of improving teaching and learning. Figure 3 summarizes the arguments described from Table 4.

The graphical representation of the perspective we call "use of technology in learning and teaching," was drawn from the text by Anderson (2008), which can be seen in Figure 4.

One aspect that stands out is that there are no intersections with the previous two perspectives in terms of citation or co-authorship. There are no common references nor mutual recognition.

Regarding geographical and institutional affiliation, the authors appearing in this graph are mainly from the US, Canada, Belgium, Holland and Israel and the Universities of Toronto (Canada), Twente (Netherlands), Tel-Aviv (Israel) and Ghent (Belgium).

Moreover, co-authorship relationships are fairly distributed which could reflect a group with strong relationships among its members. Further analysis of these relationships focusing on geographic origin shows close international links between authors. We found studies carried out jointly by authors from the US, Canada, Belgium, Holland and Israel. Many are studies funded by international organizations (OECD, mainly) and carried out in more than one country.

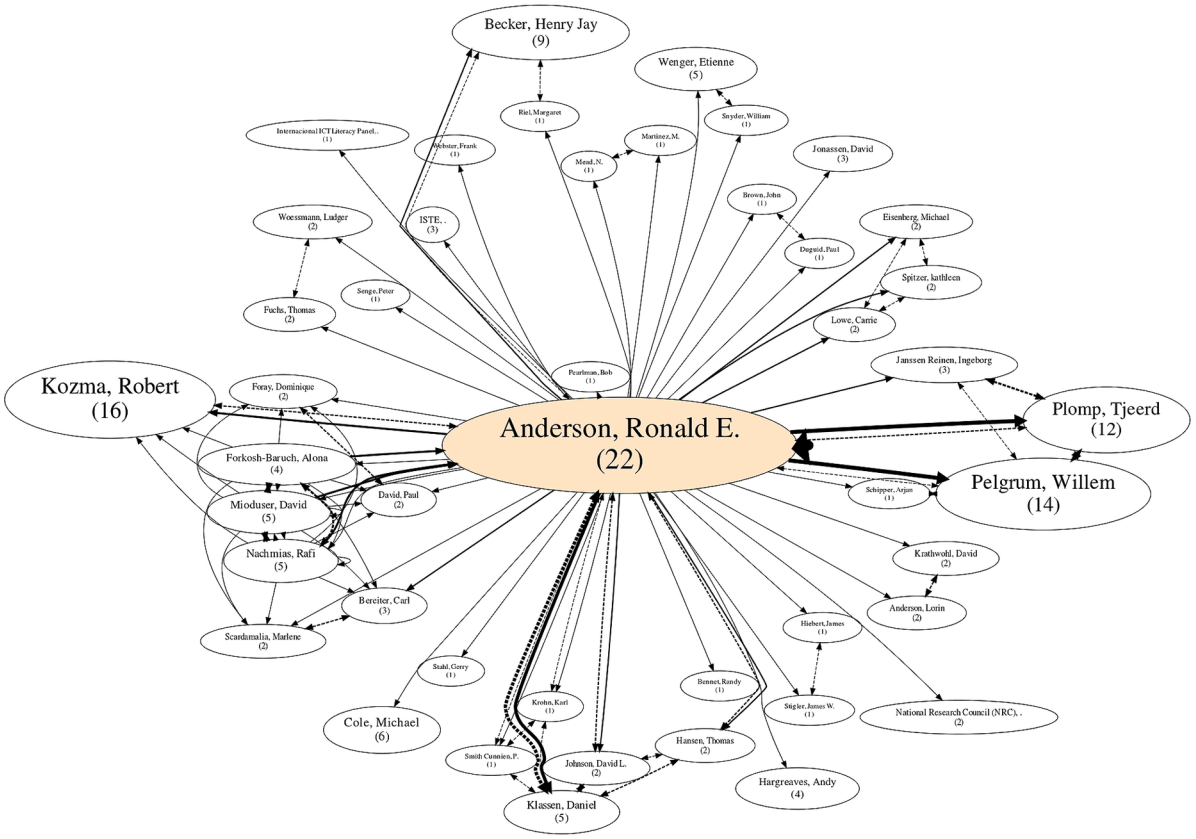
The Digital Divide Perspective

This perspective shares with the first two perspectives the idea that literacies are in a constant state of change, and the value placed on the research of new literacy practices. However, it differs in that it tends to focus on literacy practices involving

Table 4. Central arguments of the use of technology in learning and teaching perspective

Dimensions	Categories and Arguments
Definition of literacy	State (or skill set)
	Individual
	Rational
	Taught- school
Purposes of literacy	Work - Functional
	Transmission
Technological focus	Information
	Tools
	Consumption and Production
Research focus	Impact on school learning Integration/adoption of technologies in school settings
Methodological orientation	Predominantly quantitative
Definition of learning	Varies depending on study

Figure 4. Citation and co-authorship relations with respect to the text by Anderson, R. (2008). Implications of the information and knowledge society for education.



achievements in social, economic and educational power. In these studies, literacy does not refer so much to practices as it does to skills, knowledge and attitudes that enable the production of meaning.

In connection with the purposes of including of new knowledge in schools, there is strong expression of arguments involving democracy, participation and active citizenship. Subjects must be able to express themselves individually and collectively, and participate politically in public spaces. Thus, the gap regarding access and possibilities for appropriating digital technologies appear as a central research topic associated to social, ethnic and gender differences. Knowledge on the part of diverse social groups and differences in school performance are another focus of analysis.

The methodological approach combines quantitative and qualitative studies ranging from ethnography to eclectic approaches that take into account multiple sources of information with the potential to illuminate issues of underlying power.

Exponents of this perspective include the papers by Bennett, Maton, & Kervin (2008) and Selwyn (2009) where the digital natives category is discussed.

As an example, we take the study by Bennett et al (2008). This paper deals with arguments calling for a reform in the education system to address the characteristics of a supposed generation of digital natives. From an education sociology perspective, premises of those who hold this idea are discussed and challenged both theoretically and empirically.

The study brings together empirical research by other authors (generally quantitative) to show the diversity of orientations of young people in relation to new technologies.

A summary of the arguments reveals points of convergence with the abovementioned perspectives as well as a particular research focus (see Table 5).

Finally, the graphical representation of the text by Bennet (2008) shows a greater number of authors included with fewer citations for each. In addition, a reference to authors from the media education and ICT use perspectives (Livingstone, Kozma, etc.) can be seen. This could support the notion that this perspective does not truly represent a specialist language in this field. It might rather be a case of addressing a theme from different research approaches and, marginally, by an inhomogeneous group of scholars from education sociology who take the digital divide as a case study.

Moreover, the authors of this text do not appear as recognized referents (Bennet and Kervin have no citations in the database and Maton has 6, therefore, we must be careful with the interpretations that can be made from this representation.

Table 5. Central arguments of the digital divide perspective

Dimensions	Categories and Arguments
Definition of literacy	Process
	Social
	Integral
	Taught - school
Purposes of literacy	Transformative cultural citizenship
	Transmission
Technological focus	Varies depending on study
	Cultural Artifacts
	Consumption/Production
Research focus	Digital divide
Methodological orientation	Qualitative/quantitative
Definition of learning	Varies depending on study and is not explicit

CONCLUSION

The big picture shows a field of study in which specialised languages converge with different assumptions and their own legitimation criteria. One of the remarkable features of this field is that it is not possible to identify key referents: each author belongs to one perspective and seems to be unknown outside of it. This characteristic could be attributed to the novelty of the topic and to the diverse origin of the researchers who are attracted to it. It includes research from sociology, history, cultural studies, linguistic, communication and education, among many others. This feature is common to the educational field in general, however it may be more prevalent in a sphere of study of growing interest for researchers.

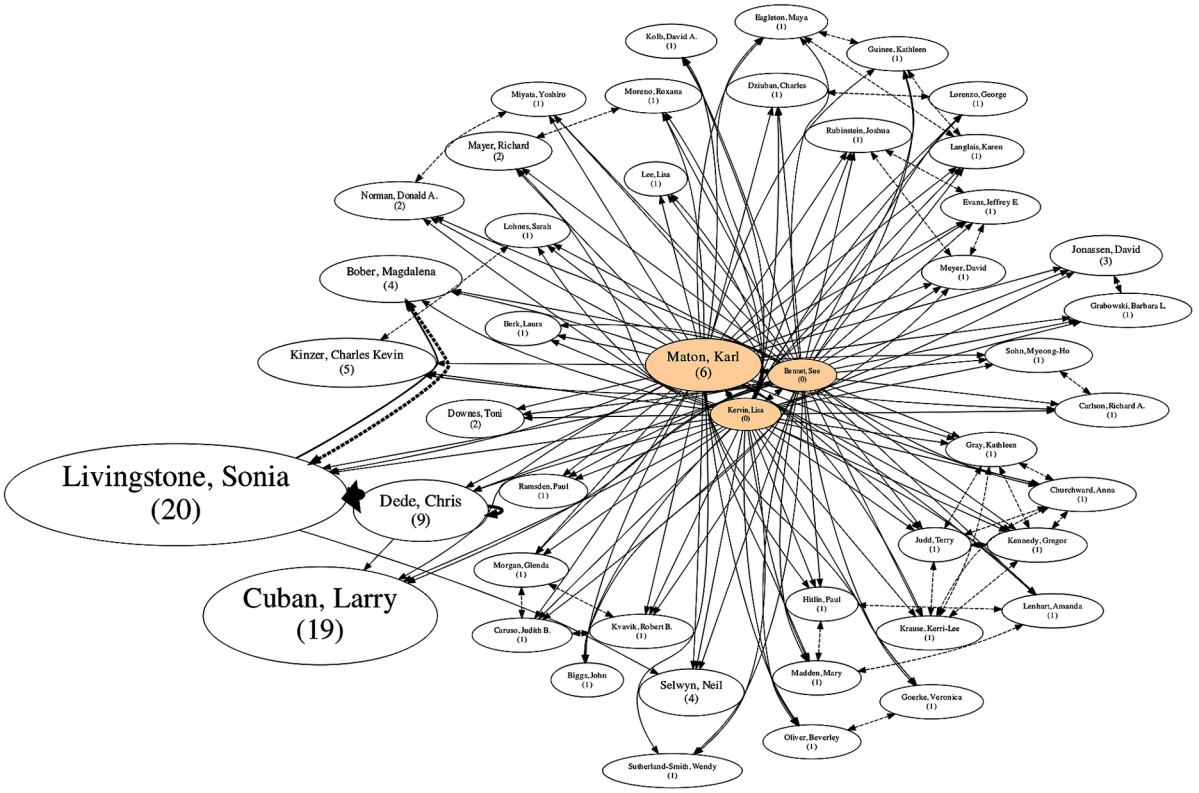
Through a qualitative analysis or the texts, we identified four main perspectives we called 'new literacies', 'media education', 'use of technology in learning and teaching' and 'digital divide. The arguments that made it possible to group the texts together involve the definition of literacy used, technologies focused on, purposes pursued including new contents in schools, the definition of learning, research topics emphasized and the methodological orientation chosen.

The qualitative analysis was complemented by the study of the whole database. This allowed us to identify the most cited authors and texts as well as the citation and co-authorship relationships between them. We used graph visualization software to explore different visual representations of these relationships and identify nuclei of authors and main production centres. This exploration also provided an initial approximation to the institutional foundation of these approaches.

In the introduction to this chapter, we proposed a series of questions stemming from the theoretical approach chosen. We refer back to them now in order to link and synthesize the results that have been described.

It was our aim to describe the forms of knowledge in the intellectual field of education with

Figure 5. Mapped Perspective of the text by Bennett, S., Maton, K., & Kervin, L. (2008). The "digital natives" debate: A critical review of the evidence.



regard to the so-called new literacies and identify the prevailing theoretical perspectives. We described four perspectives that we called "new literacies", "new media education", "use of technologies for teaching and learning" and "digital divide". Exploring the citation and co-authorship relationships between authors in these perspectives gave us an initial view of the institutional foundation of these approaches and pose the question of whether they truly represent specialized languages in a horizontal knowledge structure.

Although we identified four perspectives, we could say that two of them contain languages that are not mutually translatable, as they have specialized modes of interrogation and criteria for the construction and circulation of knowledge. The perspective we call use of technology in teaching and learning is one of these. The other is comprised of the new literacies and new media education perspectives. The digital divide perspective does not constitute a specialized language but is instead linked to the previous two, depending on the theoretical approach of each study. It is nonetheless possible to distinguish it from a perspective based on the disciplinary origins of its authors (sociology, economics, cultural studies). The papers are more or less related to the other two perspectives depending on their research aims.

It is possible to argue the conclusions by Czerniewicz (2010) on the agreement existing with respect to topics and objects of attention. While there is a general concern for education that transcends the disciplinary backgrounds of the researchers, we found that the two specialized languages had different objects of study and research interests. In the case of language linked to

literacies and media education, the main concern revolved around understanding practices in social settings associated with internet, whereas in the case of use of technologies, the focus was on improving teaching and learning through the use of ICT. In this sense, we agree with Czerniewicz that there are big differences in terms of what she calls general approach. These differences are evident in the vocabulary used; it is impossible to find general terms to describe both languages.

Overall, we can say that specialized languages having different assumptions and text legitimizing criteria converge in this field of study. It is not possible to identify key referents recognized beyond the limits of specific approaches. This feature could reflect the novelty of the study field and the diverse disciplinary origin of the researchers attracted to it. We found research from sociology, history, cultural studies, linguistics, communication and education, among others. This trait is common to the field of education in general, but it is accentuated in this field that is the focus of growing interest.Our findings have points in common with those obtained by Selwyn et al (2013). Despite the wide range of disciplines represented in the body of researchers in the field of technology education and media education, the authors maintain that this field is not completely dispersed or fragmented. In the view of the authors, the emergence of three distinct groups in this field suggests that there are fewer differences than one might suppose. That said, the authors point out the differences among the three groups identified. The groups identified by Selwyn and others are not strictly comparable with the perspectives found here due to differences in initial questions and research focus. However, an analysis of the descriptions that this author could lead us to associate the groups described as "education & teaching" and "cognition & design" to papers in what we call the 'use of technology in teaching and learning" perspective, while his description of the "social sciences & humanities" group bears more relation to the papers in what we call the "new literacies", "new media education" and "digital divide" perspectives.

At the beginning of the chapter, we also posed the question of how the positions of the actors shape the problems investigated, the modes of communication results and their dissemination. While the limits of this study may not allow a comprehensive response to this concern, we found the use of technologies perspective to have stronger links with government and international agencies. These ties could explain the presence of strong concerns regarding the curriculum as well as learning and teaching outcomes. Furthermore, it could explain a more action-oriented discourse; seeing as texts generally contain recommendations and standards for measuring achievements.

For the purposes of this book it is important to analyse the contributions that each perspective can make to Higher Education in the field of Engineering and Architecture Education.

As we could see in further research, the "use of technologies in teaching and learning" is the most influent perspective in the educational field. In terms of affordances, this perspective focuses on central topics like teaching and how to improve the results of learning. Some efforts in this perspective also address the conditions that are necessary for an effective integration of technologies in education such as institutional culture, teacher's training, etc. In addition, there are many research projects studying the use of specific resources, for instance, the importance of use mobile learning (m-learning) in the field of Architecture and Building Construction (Redondo, Fonseca, Sánchez y Navarro. 2010) or the use of multimedia in educacion (Maver & Petric, 1999) . However, to adopt this perspective as the only one in Higher Education might have some limits.

In first term, this perspective tends to prioritise information technologies and activities related to information processing and it under-estimates its

feature as communicational environments. In the case of architecture, it may lead to undervaluing the artistic and expression aspects. This perspective also see the technologies as tools and prioritise its inclusion in teaching as resources to teach, forgetting the importance of treating them as object of knowledge that need to be explicitly taught and analysed. The latter aspect is particularly important in careers in which the proficiency in the use of certain technologies is essential to successfully perform as professional. In other study (Gewerc, Montero, Pernas & Alonso, 2011), we found that the technologies that are used in the professional life are not part of the career plan in many universities. It is expected that students are familiar with this tools, therefore it is not consider important to teach about them or to explore different options and analyse them according to disciplinary criteria.

In the same vein, the perspectives "new media education" and "new literacies" would allow to look these new media with a less urgent and more critical attitude. On the one hand, they have a wider notion of technologies and they emphasize the communicational and expressive attributes that are core aspects of Architecture education. On the other hand, they address the importance of media education, advocating the inclusion of media as object of study in all levels of education. An example of this is reported by the Sarricchio & Badella (2011).

Finally, the perspective of the digital gap reminds us that access to technologies is still unequal and, hence, students in Higher Education have had uneven chances to learn about the tools that are required in their careers. If universities do not take their responsibility to provide new opportunities for students to acquire the skills needed, it not only increases the existing gap, but also undermine the outcomes of learning.

In short, we can highlight the importance of working aspects that fully include the three perspectives in the engineers and architects education. It is not only about necessary technologies for the development of the profession, but also to imagine a way to integrate new literacies that professionals need to acquire in the XXI century.

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KEY TERMS AND DEFINITIONS

Curricular Policies: (in this case): Policies produced by official agents (state) in order to regulate and shape knowledge transmitted in the educational field.

Horizontal Knowledge Structures: A series of specialized languages with different modes of interrogation and criteria for the construction and circulation of knowledge.

Intellectual Field of Education: (Bernstein): Intellectual field in which new ideas about education are created, transformed and selected in a complex social space of institutions and agents with diverse institutional base and conflicting interests.

Pedagogic Discourse: principle for appropriating other discourses and relating them to the purpose of their transmission and acquisition.

Theoretical Perspectives in the Field of New Literacies: Perspectives that share assumptions about object of knowledge, research methods and conceptions of literacy and technologies.

ENDNOTES

[1] This quote is originally in Spanish.
[2] This quote is originally in Spanish.
[3] This quote is originally in Spanish.

Chapter 6
Serious Games as Positive Technologies

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ABSTRACT

Serious games are growing rapidly both as an industry and a field of academic research. They have been able to shape new opportunities for individual and collective learning and training, showing a discrete effectiveness. Further, serious games have been capable of supporting health and well-being. That is why they can be considered as positive technologies. Positive Technology is an emergent field whose goal is to investigate how Information and Communication Technologies (ICTs) can be used to empower the quality of personal experience The aim of the present chapter is to discuss the role of serious games as positive technology, analyzing how they can influence both individual and interpersonal experiences by fostering positive emotions, promoting engagement, as well as enhancing social integration and connectedness.

INTRODUCTION

Serious games are digital games used for purposes other than mere entertainment. Since their infancy in the late 1990s, they have found important applications in different areas, such as education, industry, architecture, engineering, military and medicine, acquiring a prominent role in the actual knowledge society (Bergeron, 2006; Ritterfeld, Cody, & Vorderer, 2009). By fostering continuous learning experiences blended with ludic and engaging affordances, serious games have in fact been able to shape new opportunities for individual and collective learning and training, showing a discrete effectiveness (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Girard, Ecalle, & Magnan, 2013; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013).

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In particular, serious games have provided successful answers to two specific challenges of education and training in the 21st century (Bekebrede, Warmelink, & Mayer, 2011; Prensky, 2003): (a) the presence of a new generation of learners and trainees grown up in a fully digitalized society and (b) the need for a more engaging and motivating way of imparting skills, knowledge, or attitude that can be used in the real world (Bergeron, 2006).

Further, serious games have been capable of supporting wellness and promoting positive emotions. That is why they can be considered as "positive technologies" (Argenton, Triberti, Serino, Muzio, & Riva, 2014). Positive Technology is an emergent field based on both theoretical and applied research, whose goal is to investigate how Information and Communication Technologies (ICTs) can be used to empower the quality of personal experience (Botella et al., 2012; Riva, Baños, Botella, Wiederhold, & Gaggioli, 2012; Wiederhold & Riva, 2012). Based on Positive Psychology theoretical framework (Seligman & Csikszentmihalyi, 2000), Positive Technology approach claims that technology can increase emotional, psychological and social well-being. This assumption opens a totally new perspective in the traditional digital gaming literature that has deeply investigated the negative impact of gaming, with respect to violence (Anderson et al., 2003; Gentile & Anderson, 2003; Wouters et al., 2013), addiction (Van Rooij, Meerkerk, Schoenmakers, Griffiths, & van de Mheen, 2010; Van Rooij, Schoenmakers, Vermulst, Van Den Eijnden, & Van De Mheen, 2011) or social isolation (Colwell & Payne, 2000; Pezzeca, 2009).

The aim of the present chapter is to discuss the role of serious games as positive technology, analysing how they can influence both individual and interpersonal experiences by fostering positive emotions, promoting engagement, as well as enhancing social integration and connectedness. These aspects will be discussed with particular regard to the field of Engineering and Architecture Education.

Background

Positive Technology is the scientific and applied approach to the use of technology for improving well-being and the quality of personal experience (Botella et al., 2012). This approach is strongly based on Positive Psychology framework that emerged as the scientific study of positive personal experience, positive individual traits, and positive institutions (Seligman & Csikszentmihalyi, 2000; Seligman, 2003). By focusing on human strengths, healthy processes, and fulfillment, Positive Psychology aims to improve the quality of life, as well as to increase wellness, and resilience in individuals, organizations, and societies (Delle Fave, Massimini, & Bassi, 2011; Seligman, Steen, Park, & Peterson, 2005). Rather than representing a new formal sector or a new paradigm, Positive Psychology is a novel perspective to studying human behavior where the link with accurate and scientific methodological practices (Seligman et al., 2005) has become the engine of interventions to study and promote the optimal expression of thought, emotions and behaviors. In particular, Keyes and Lopez (2002) argued that positive functioning is a combination of three types of well-being: (i) hedonic or emotional well-being, (ii) eudaimonic or psychological well-being, and (iii) social well-being. This means that Positive Psychology is mainly focused on three characteristics of personal experience: affective quality, engagement/actualization, and connectedness.

Based on Positive Psychology assumptions, Positive Technologies can be used to manipulate the quality of human experience through its structuring, augmentation and/or replacement in order to generate well-being at these three key levels (Botella et al., 2012; Wiederhold & Riva, 2012). As a consequence, Positive Technologies can be classified as follow:

- **Hedonic Technologies:** Mood-altering devices, which use ICTs to induce positive and pleasant experiences;

- **Eudaimonic Technologies:** Systems designed to support individuals in reaching engaging and self-actualizing experiences;
- **Social /Interpersonal Technologies:** Technologies that seek to improve the connectedness between individuals, groups, and organizations.

The hedonic side of Positive Technology analyzes the ways technologies can be used to produce positive emotional states. Unlike negative emotions that are essential to provide a rapid response to perceived threats, positive emotions can expand cognitive-behavioral repertoires and help to build resources that contribute to future success, as highlighted by the "broaden-and-build" model (Fredrickson, 2000, 2001). According to Fredrickson, positive emotions broaden, on the one hand, the organism's possibilities with undefined response tendencies that may lead to adaptive behaviors and mitigate the impact of negative stressors. The elicitations of positive emotions, for example, make attentional processes more holistic and gestaltic (Fredrickson & Branigan, 2005), stimulate a more flexible, intuitive, receptive and creative thinking (Fredrickson, Mancuso, Branigan, & Tugade, 2000). Moreover, by encouraging a broadened range of actions, positive emotions build over time enduring physical, psychological, and social resources. For example, correlation with a faster recovery from cardiovascular diseases (Fredrickson & Levenson, 1998), an increase of immune function and lower levels of cortisol have been highlighted (Tugade & Fredrickson, Fredrickson, 2004). Moreover, the presence of positive emotions is an effective predictor of the level of happiness of individuals (Fredrickson & Joiner, 2002) and longevity (Pressman & Cohen, 2005), triggering a virtuous circle, that implements the possible use of other positive experiences.

Different devices have proven to be effective from this point of view. For example, the Butler Project, a technological e-health platform designed to deliver health care to the elderly (Botella et al., 2009) appeared to be effective in promoting positive emotions and decreasing negative feelings. The platform is able to support user experience on three levels: diagnosis (mood monitoring, alert system, management reports), therapy (training in inducing positive moods, memory work), and entertainment (e-mail, chat, video, photo albums, music, friend forums, accessibility to the Internet). Other studies explored the potentiality of emerging mobile devices to exploit the potential of positive emotions (Serino, Cipresso, Gaggioli, & Riva, 2013). For instance, Grassi, Gaggioli, & Riva (2009), showed that relaxing narratives supported by multimedia mobile phones were effective to enhance relaxation and reduce anxiety in a sample of commuters. Further, the role of emotions in human-computer interaction has been deepened by emerging trends such as engineering aesthetics (Liu, 2003; Locher, Overbeeke, & Wensveen, 2010; Sonderegger & Sauer, 2010). Since aesthetic experiences are those that are immersive, infused with meaning, and felt as coherent and complete (Parrish, 2009), this approach is focused understanding how interfaces on the creation of artifacts that are attractive and pleasurable. In a study made by Sonderegger & Sauer (2010), two functionally identical mobile phones were manipulated with regard to their visual appearance (highly appealing vs not appealing) to determine the influence of appearance on perceived usability, performance measures and perceived attractiveness. Results showed that the visual appearance of the phone had a positive effect both on and the perception of usability and performance, leading to reduced task completion times for the appealing models.

On the basis of Russell's model, many researchers have acknowledged the possibility to modify the affective quality of an experience by manipulating the "core affect" (Russell & Barrett, 1999; Russell, 2003). This is a neurophysiological state corresponding to the combination of hedonic valence and arousal that endows individuals with a sort of "core knowledge" about the emotional features of their emotional experience. The "core

affect" can be experienced as free-floating (mood) or attributed to some causes (and thereby begins an emotional episode).

In this view, an emotional response is the attribution of a change in the core affect given to a specific object (affective quality).

Recent researches showed that the core affect could be manipulated by Virtual Reality (VR). In particular, Riva and Colleagues tested the potentiality of Virtual Reality (VR) in inducing specific emotional responses, including positive moods (Riva et al., 2007) and relaxing states (Villani, Lucchetta, Preziosa, & Riva, 2009; Villani, Riva, & Riva, 2007). Other studies have combined Mood Induction Procedures (procedures designed to provoke transitional mood states in non-natural situations in a controlled manner) (Velten, 1968) with Virtual Reality to induce positive emotions, like happiness and relaxation (Baños et al., 2006).

As noted by Serino and colleagues (Serino et al., 2013), the potential advantages of using VR technology in inducing positive emotions are essentially two:

- **Interactivity:** To motivate participants, including video and auditory feedback;
- **Manipulability:** To tailor each session in order to evaluate user's idiosyncratic characteristics and to increase task complexity as appropriate.

The second area positive technologies are strongly connected is eudaimonic well-being. Eudaimonic well-being is associated with the possibility to fully realize human potential through the exercise of personal virtues in pursuit of goals that are meaningful to the individual and society (Delle Fave et al., 2011). Thus, this approach focuses on the growth of individuals as a whole, rather than merely emphasizing the pursuit to pleasure and comfort. Happiness no longer coincides with a subjective form of well-being, but with a psychological one. This is based on 6 elements (Diener, 2000; Diener, Sapyta, & Suh, 1998; Pavot & Diener, 2008):

- **Self-Acceptance:** Characterized by awareness and a positive attitude towards personal qualities and multiple aspects of the self, including unpleasant ones;
- **Positive Relationships with Others:** Determined by the ability to develop and maintain social stable relationships and to cultivate empathy, collaboration and mutual trust;
- **Autonomy:** Reflected by the ability of seeking self-determination, personal authority, or independence against conformism;
- **Environmental Mastery:** Based on the ability to change the external environment, and to adapt it to personal needs or goals;
- **Purpose in Life:** Marked by the presence of meaningful goals and aims in the light of which daily decisions are taken;
- **Personal Growth:** Achievable throughout a continuous pursuit of opportunities for personal development.

Another author that has fully interpreted the complexity of the eudaimonic perspective is Positive Psychology pioneer Mihaly Csikszentmihalyi who formalized the concept of flow. The term expresses the feeling of fluidity, and continuity in concentration and action reported by most individuals in the description of this state (Csikszentmihalyi, 1991). In particular, flow, or optimal experience, is a positive, complex and highly structured state of deep involvement, absorption, and enjoyment (Jackson & Csikszentmihalyi, 1999). The basic feature of this experience is a dynamic equilibrium perceived between high environmental action opportunities (challenges) and adequate personal resources in facing them (skills). Additional characteristics are

deep concentration, clear rules and unambiguous feedback from the task at hand, loss of reflective self-consciousness, control of one's actions and environment, alteration of temporal experience, and intrinsic motivation.

Scholars in the field of human–computer interaction are starting to recognize and address the eudaimonic challenge too. For example, Rogers calls for a shift from "proactive computing" to "proactive people," where "technologies are designed not to do things for people but to engage them more actively in what they currently do" (Rogers, 1990). Moreover, the theory of flow has been extensively used to study user experience with Information and Communication Technologies. It is the case of internet (Chen, Wigand, & Nilan, 2000), virtual reality (Sanchez-Vives & Slater, 2005), social networks (Mauri, Cipresso, Balgera, Villamira, & Riva, 2011), and video-games (Admiraal, Huizenga, Akkerman, & Dam, 2011; Jegers, 2007; Nacke & Lindley, 2009). In fact, all these media are able to support the emergence of a flow state, as they offer an immediate opportunity for action, and the possibility to create increasingly challenging tasks, with specific rules, as well as the opportunity to calibrate an appropriate and multimodal feedback.

In addition, some researchers have drawn parallels between the experience of flow and the sense of presence, conceived as the subjective perception of "being there" in a virtual environment (Slater, 1999). Both experiences have been described as absorbing states, marked by a merging of action and awareness, loss of self-consciousness, and high involvement and focused attention on the ongoing. On these premises, Riva and colleagues postulated the power of "transformation-of-flow"-based strategies (Riva et al., 2012). They can be conceived as individuals' ability to draw upon an optimal experience induced by technology, and to use it to promote new and unexpected psychological resources and sources of involvement.

At the third level, the challenge for Positive Technology is concerned with the use of new media to support and improve the connectedness between individuals, groups, and organizations, and to create a mutual sense of awareness. This is essential to the feeling that other participants are there, and to create a strong sense of community at a distance. Short and colleagues (Short, Williams, & Christie, 1976) introduce the term "social presence" to indicate the degree of salience of the other person in a mediated environment and the consequent salience of their interpersonal interaction. On this point, Riva and colleagues (Riva et al., 2007) argued that an individual is present within a group if he/she is able to put his/her own intentions (presence) into practice and to understand the intentions of the other group members (social presence). Techniques to promote such a "sense of being with another" throughout a medium have a long history, going back to the first stone sculptures that evoked a sense of some other being in the mind of an ancestral observer.

Assembling these basic concepts with the potential of the world wide web in its most recent version (web 2.0), enterprise 2.0 was born in the business context. It implies the emerging use of social software platforms within companies to facilitate the achievement of business objectives (McAfee, 2009). Thus, Enterprise 2.0 allows to work on reputation, (by both monitoring the internal reality of the organization, and identifying the dynamics implemented by external stakeholders and audiences), collaboration (by developing internal communities), communication (by stimulating the development of interactive exchanges), and connectedness (by enriching the relational and logical transmission of information).

Other interesting phenomena linked to the interpersonal dimension are crowdsourcing and Collaborative Innovation Networks (COINs). The former represents an online, distributed problem-solving and production model that indicates the procurement of a set of tasks to a particularly broad and undefined group of individuals, called to collaborate through Web 2.0 tools (Estelles-Arolas & Gonzalez-Ladron-de-Guevara, 2012). The latter,

indicates a "cyber-team of self-motivated people with a collective vision, enabled by the Web to collaborate in achieving a common goal by sharing ideas, information and works" (Gloor, 2007).

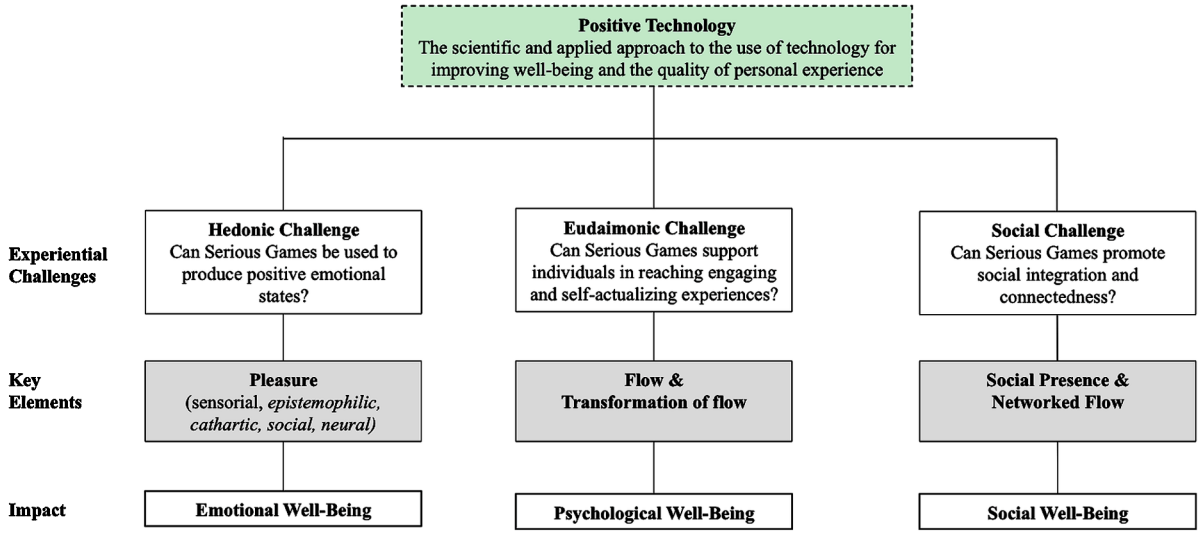
All these technologies can promote the development of a peak collaborative state experienced by the group as a whole and known as "networked flow" (Gaggioli, Riva, Milani, & Mazzoni, 2013). Sawyer (2003, 2008), who referred to this state with the term of group flow, identified several conditions that facilitate its occurrence: the presence of a common goal, close listening, complete concentration, control, blending egos, equal participation, familiarity, communication and the potential for failure. As noted by Gaggioli and colleagues (2013), networked flow occurs when high levels of presence and social presence are matched with a state of "liminality". In particular, three pre-conditions have to be satisfied:

- Group members share common goals and emotional experiences so that individual intentionality becomes a *we-intention* able to inspire and guide the whole group;
- Group members experience a state liminality, a state of "being about" that breaks the homeostatic equilibrium previously defined;
- Group members identify in the ongoing activity the best affordances to overcome the situation of liminality.

SERIOUS GAMES AS POSITIVE TECHNOLOGIES

As noted by the World Health Organization (1948), health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Serious games have proven to be strongly related to maintaining and restoring good health (Brox, Fernandez-Luque, & Tøllefsen, 2011; McCallum, 2012; Stapleton, 2004; Wattanasoontorn, Boada, García, & Sbert, 2013). For example, according to the taxonomy proposed by Wattanasoontorn and colleagues (2013), they can support patients by monitoring health, detecting irregular symptoms, treating physical and mental

Figure 1. Serious Games as Positive Technologies



issues and contributing to the rehabilitation process. Further, serious games can assist people to increase their well-being, physically, mentally and socially (Brooks, Brahnam, & Jain, 2014). As a consequence, they are able to address the three main challenges identified by Positive Technology.

The Hedonic Challenge

Games can elicit several emotional states (Anolli, Mantovani, Confalonieri, Ascolese, & Peveri, 2010). Many representations of players' affective states have been used in previous studies like anxiety, frustration, engagement, distress scales, and the valence-arousal space (Anderson & Ford, 1986; Freeman, 2004). However, serious Games and games in general are strictly connected to positive emotions, and to a wide variety of pleasant situational responses that make gameplay the direct emotional opposite of depression (McGonigal, 2010).

At first, serious games can evoke a *sensorial pleasure* throughout graphics, usability, game aesthetic, visual and narrative stimuli. Secondly, serious games foster an *epistemophilic pleasure* by bridging curiosity with the desire of novelty within a protected environment where individuals can experience the complexity of their self, and developing mastery and control. In other words, they are able to recreate a "magic circle" (Huizinga, 1950) that enforces individual agency, self-confidence and self-esteem (Anolli et al., 2010), by sustaining a process of acknowledgement of personal ability to perform well, solve problems, and manage with difficulties. Hence, empowered by new media affordances and possibilities, serious games can promote a dynamic equilibrium between excitement and security.

Thirdly, serious games promote the *pleasure for victory* and, by supporting virtual interactions with real people, they nurture a *social pleasure*, promoting collaborative and competitive dynamics, communication and sharing opportunities, even outside the context of the game (Anolli et al., 2010).

Games have also been traditionally recognized as marked by a *cathartic pleasure* as they represent a relief valve for emotional tensions, anger and aggressiveness (Wouters et al., 2013).

Finally, pleasure has a *neural* counterpart. An interesting example is that of dopamine, a neurotransmitter that affects the flow of information in the brain and that is often involved in pleasant experiences, as well as in different forms of addiction and learning. In a classic study made by Koepp and colleagues to monitor the effects of video games on brain activity, a significant increase of dopamine (found in a quantity comparable only to that determined by taking amphetamines) was measured (Koepp et al., 1998).

Good examples of Serious Games explicitly designed to foster positive emotion are *The Journey* to Wild Divine" (http://www.shokos.com/The_Journey_to_Wild_Divine.html) and Eye Spy: the *Matrix*, *Wham!,* and *Grow your Chi*!, developed in Dr Baldwin's Lab at McGill University (http://selfesteemgame

s.mcgill.ca). In *The Journey to Wild Divine* the integration between usable biofeedback sensors and a computer software allows individuals to enhance their subjective wellbeing throughout a 3D graphic adventure. Here, wise mentors teach the skills to reduce stress, and increase physical and mental health.

Eye Spy: the Matrix, *Wham!,* and *Grow your Chi*! are indeed projects whose goal is to empower people with low self-esteem respectively by working on ignoring rejection information, throughout positive conditioning, or by focusing on positive social connections (Baccus, Baldwin, & Packer, 2004; Dandeneau & Baldwin, 2004).

Further, knowledge and awareness of hedonic principles can be fundamental to enhance learning effectiveness and retention (Connolly, Boyle,

MacArthur, Hainey, & Boyle, 2012). For example, in the field of software engineering typical lectures allows only passive learning and both projects and practice exercises are not enough to help students to cope with many of the issues the will face when working on real-world software engineering processes (Armarego, 2002). To address this problem, Baker, Navarro and van der Hoek (2005) developed *Problems and Programmers*, an educational card game that simulates the complexity of software engineering process. The authors emphasized the role of both pleasure for victory and social pleasure by making the game highly competitive: each player wears the shoes of project manager that has to complete the project before any of the opponents do. To achieve such a complex goal, users have to manage a complex range of resources, including time, money and the client's demands regarding the reliability of the produced software. Secondly, sensorial pleasure has been taken in deep consideration too. Entertaining character descriptions, humorous character illustrations, and unexpected situations further add to this quality. Another good example is the one presented by Coller and Scott (Coller & Scott, 2009) that used the hedonic affordance of a video-game during a course in mechanical engineering. Students were given the task of writing computer programs to race a simulated car around a track. Results showed that students using the game demonstrated deeper learning and spent roughly twice as much time, outside of class, on their homework.

The Eudaimonic Challenge

Bergeron (Bergeron, 2006) defined serious games as interactive computer applications, with or without a significant hardware component, that (i) have challenging goals, (ii) are fun to play with and/or engaging, (iii) incorporate some concepts of scoring, (iv) impart to the user skills, knowledge, or attitude that can be applied in the real world.

Interestingly, all of these aspects can be easily overlapped to Csikszentmihalyi's theory of flow. Games are in fact "flow activities" (Csikszentmihalyi, 1991; 2000) as they are intrinsically able to provide enjoyable experiences (McGonigal, 2010), creating rules that require the learning of skills, defining goals, giving feedback, making control possible, and fostering a sense of curiosity and discovery.

In addition, the intrinsic potential of flow that characterizes serious games can be even empowered by (i) identifying an information-rich environment that contains functional real world demands; (ii) using the technology to enhance the level of presence of subjects in the environment, and (iii) allowing the cultivation, by linking this optimal experience to the actual experience of the subject (Ijsselsteijn & Riva, 2003). To achieve the first two steps, it is fundamental to look at the following game design elements (Sweetser & Wyeth, 2005):

- **Concentration:** Serious games should stimulate a mental focus on in-game dynamics, by providing a set of engaging, differentiated and worth-attending stimuli that limit the influence of external variables. Along with other aspects, concentration can result in hyperlearning processes that consist of the mental ability to totally focus on the task by using effective strategies aligned with personal traits (Csikszentmihalyi, 1991);
- **Challenge:** As noted by Gee (Gee, 2003), who claims that the game experience should be "pleasantly frustrating", challenges have to match players' skills/level and to support their improvement throughout the game. During specific stages of the game, "Fish tanks" (stripped down versions of the real game, where gameplay mechanisms are simplified) and "Sand boxes" (versions of the game where there

is less likelihood for things to go wrong) can support this dynamism;

- **Player Skills:** Games must support player skills and mastery throughout game usability, and specific support systems and rewards;
- **Control:** It is fundamental for players to experience a sense of control over what they are doing, as well as over the game interface, and input devices;
- **Clear Goals:** Games should provide players with specific, measurable, achievable, responsible and time-bounded goals;
- **Feedback:** Players have to be supported by feedback on the progress they are making, on their action, and the ongoing situations represented in the virtual environment;
- **Immersion:** Players should become less aware of their surroundings and emotionally involved in the game dynamics;
- **Social Interaction:** Games should create opportunities for social interaction by supporting competition, collaboration, and sharing among players.

In the field of Engineering and Architecture Education, the flow model has also been explicitly used by Mildner et Al. (2012). The game is commonly used in classrooms to deliver architectural knowledge to young students. The player starts the game in the role of a young student who has to write an essay on stylistic eras of architecture and looks for the advice of a professor in the neighborhood. Before the professor can explain anything relevant a lab accident happens in which the student gets trapped in a time machine the professor possesses. The student then travels through different time epochs where he can directly experience 3D models of building and architectures. In order to travel back to the present time the player has to collect energy modules to fully repair the time machine. In contrast to other educational games where learning and fun phases are strictly separated, the game avoids this distinction: the knowledge itself is implicitly embedded into the game's story line. This is fundamental to foster flow in terms of concentration, control, and immersion. Further, the game was developed to dynamically adapt task difficulty to the player's skill level. A tutoring system was chosen so that the player can actively ask for help if he or she is stuck at a certain point. Similarly, the game can automatically detect if a player needs help by acquiring specific performance measure, like the time the player needs for solving a task.

In the same field, *Capture Game* (http://www.txchange.nl/portfolio-item/capture-game/), realized by T-Xchange, referred to the challenge and skills balance to develop challenging issues for young architects who wanted to train their managerial skills. In the serious game, complexity comes from multiple interactions between operational needs, capability and services that are aligned with the quality of the action given by the player.

Numerous case studies have been realized to analyze the usefulness of flow as serious games quality measure (Bellotti, Kapralos, Lee, Moreno-Ger, & Berta, 2013; Kiili, Lainema, de Freitas, & Arnab, 2014; Kiili, Perttula, Lindstedt, Arnab, & Suominen, in press). Results indicated that flow is an appropriate construct to assess the quality of game experience (Ermi & Mäyrä, 2005; Oksanen, 2014) and that its measurement can facilitate game evaluation and design practices (Bergeron, 2006; Kiili et al., 2014), especially for eudaimonic serious games.

Another interesting example of an eudaimonic serious game is *Reach Out Central* (ROC), developed by ReachOut.com (http://www.reachoutpro.com). It is a Cognitive-Behaviour therapy game that encourages users to develop psychological well-being. Studied for young people aged 14-24, ROC is a single-player role play game with innovative 3D graphics and real-life scenarios and characters. Here, players can see how their decisions and reactions affect their moods, and apply skills they learn offline in their day-to-day lives. An evaluation conducted by Shandley and

colleagues (Shandley, Austin, Klein, & Kyrios, 2010; Shandley, Klein, & Austin, 2008) found that ROC reduced psychological distress, alcohol use, and improved life satisfaction, resilience, and problem-solving abilities. Another great example is *Superbetter,* developed by Jane McGonigal (https://www.superbetter.com/). SuperBetter helps people their life goals by working on personal resilience. The application of the aforementioned elements supports people being curious, optimistic and motivated and promotes high levels of user engagement.

The Social Challenge

Cantamesse, Galimberti, & Giacoma (Cantamesse, Galimberti, & Giacoma, 2011) examined the effect of playing the online game World of Warcraft (WoW), both on adolescents' social interaction and on the competence they developed on it. The in-game interactions, and in particular conversational exchanges, turn out to be a collaborative path of the joint definition of identities and social ties, with reflection on in-game processes and out-game relationships. Other good examples of specifically designed SGs can be found in the field of organizational management and education. For instance, *Everest V2* (2011), was developed by the Harvard Business School to promote leadership and team working, and *Woodment* (2010) was presented as an educational web-based collaborative multiplayer SG. Another example is *TeamUp* (2013) developed by The Barn in collaboration with the Delft University of Technology and Accenture and winner of the SAGANET Award 2013 (Mayer, van Dierendonck, van Ruijven, & Wenzler, 2013). In the field of both architecture and engineering, various collaborative interfaces have been developed for spatial planning. For example, Simlandscape (Ligtenberg, de Vries, Vreenegoor, & Bulens, 2010) is a serious game that aims at using real geo-information and helping students to develop real area plan-scenarios and to be aware of the resulting impact they have on the areas involved. The whole simlandscape process takes place in three types of collaborative settings (Slager, Ligtenberg, de Vries, & de Waard, 2007):

- **Personal Space:** To support the design and creation of plans in privacy
- **Joint Space:** To support the development of a coalition between actors to create plans together
- **Public Space:** To support public plan creation and plan evaluation

In these games, social presence and networked flow are fundamental (Brom et al., 2014). These principles have been also used to support Participatory Design practices (Sanders, 2002), with users and other stakeholders playing a key role in all the stages relating to design, development and evaluation of a specific project (Corrigan, Zon, Maij, McDonald, & Mårtensson, 2014). Participatory Design can improve communication, control of the project, innovation and creativity. Connoly and colleagues (Connolly, Stansfield, & Hainey, 2007) presented the SDSim Game, a serious game where a team has to manage and deliver a number of software development projects. In the game each player has a specific role, such as project manager, systems analyst, systems designer or team leader with specific tasks. During the game, the team is provided with background information and must produce an high-level product that addresses the clients' requirements and manage a limited amount of resources. To do so, players must move through game-levels, interact among them and 'talk' to the nonplayer characters (NPCs) in the game.

Some studies have addressed the relationship between social presence and immersion in games finding controversial results (Cairns, Cox, Day, Martin, & Perryman, 2013; Oksanen, 2014; Sweetser & Wyeth, 2005; Yoo & Alavi, 2001). On the one hand, there are those who claim that the presence of others, even mediated via online play, would require players to think about the other players and so draw their attention away

from the thinking about the game, determining low level of immersion (Sweetser & Wyeth, 2005). Other studies have indeed highlighted the opposite. For example, Cairns et al. (2013) run three experiments that showed that players were more immersed when playing against another person than playing against a computer and that there was not significant different in the levels of immersion whether the other person was present in the room or not. Similarly, Oksanen (2014) found that the sociability of the environment strengthen the emergence of social presence and that it can also contribute to the formation of positive game experiences. Moreover, social presence has a specific role, particularly in collaborative games, to open communication, critical thinking, group cohesion, supportive interaction and negotiation (Kreijns, Kirschner, & Jochems, 2003, 2002). High levels of social presence are predictors of learning (Gunawardena, 1995) and they are correlated to high levels of enjoyment (Gajadhar, de Kort, & IJsselsteijn, 2008), social interaction (Tu & McIsaac, 2002) and group cohesion (Yoo & Alavi, 2001).

CONCLUSION

Serious games are digital games used for purposes other than mere entertainment. By using the latest simulation and visualization technologies, SGs are able to contextualize the player's experience in stimulating and realistic environments (situated cognition) (Bellotti et al., 2013) that foster practical learning experiences blended with ludic and engaging affordances.

In this paper we discussed the role of serious games as positive technologies. According to Positive Psychology theoretical framework and Positive Technology approach, we explored how these applications are able to promote hedonic well-being, eudaimonic well-being and social well-being.

First of all, serious games can foster positive emotional states by enhancing the different forms of pleasure they are intrinsically made of. In particular, we discussed the importance of sensorial, epistemophilic, social, cathartic and neural pleasure.

Secondly, serious applications for computer game technologies can be associated with flow experiences and, thus, with eudaimonic well-being. Throughout high level of presence and flow, serious games can, in fact, promote optimal experiences marked by absorption, engagement, and enjoyment. Numerous studies have been realized to analyze the usefulness of flow as serious games quality measure (Bellotti, Kapralos, Lee, Moreno-Ger, & Berta, 2013; Kiili, Lainema, de Freitas, & Arnab, 2014; Kiili, Perttula, Lindstedt, Arnab, & Suominen, in press). Results indicated that flow is an appropriate construct to assess the quality of game experience (Ermi & Mäyrä, 2005; Oksanen, 2014) and that its measurement can facilitate game evaluation and design practices (Bergeron, 2006; Kiili et al., 2014), especially for eudaimonic serious games.

Finally, serious games are able to increase connectedness and integration. To achieve such a complex goal they have to work on a mutual sense of awareness, as well as social presence and situations of liminality. In this way, groups can access high levels of social interaction and peak creative states, known as networked flow experiences, that are based on shared goals and emotions, collective intentions, and proactive behaviors. These experiences have a specific role, particularly in collaborative games, to open communication, critical thinking, group cohesion, supportive interaction and negotiation (Kreijns, Kirschner, & Jochems, 2003, 2002). High levels of social presence and networked flow are predictors of learning (Gunawardena, 1995) and they are correlated to high levels of enjoyment (Gajadhar, de Kort, & IJsselsteijn, 2008), social interaction (Tu & McIsaac, 2002) and group cohesion (Yoo & Alavi, 2001).

On the one hand, knowledge and awareness of hedonic, eudaimonic and social principles can be both fundamental to enhance learning effectiveness and retention (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). For example, in the field of engineering and architecture typical lectures allows only passive learning and both projects and practice exercises are not enough to help students to cope with many of the issues the will face when working on real-world challenges (Armarego, 2002). An effective balance of the three levels can support students not only to become active and engaged learners, but also to improve their well-being and contribute to the development of sustainable communities of practices.

On the other, the concrete application of Positive Technology principles may be fundamental to improve user-centered design models. One of the most important aspects to analyse when considering serious and computer games from a scientific point of view is game experience (Poels, De Kort, & Ijsselsteijn, 2007; Sweetser & Wyeth, 2005; Takatalo, Nyman, & Laaksonen, 2008). Attempts to clearly define the construct are indeed scarce and the wide variety of games genres and the complex, subjective and dynamic nature of the idea of experience (Takatalo et al., 2008) makes it hard to find a common definition. However, many authors agree (Coller & Scott, 2009; De Kort, Ijsselsteijn, & Poels, 2007; Ermi & Mäyrä, 2005) on the importance of elements like positive affects, flow and social presence that are central in the Positive Technology framework.

Despite the impressive growth of SGs applications, only a few of them have been tested and scientifically considered from an empirical point of view. This is a major challenge for future research and investigation. Positive Technology approach can address this issue not only by creating a concrete background for both theoretical and applied research, but also supporting game design processes.

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KEY TERMS AND DEFINITIONS

Eudaimonic Technologies: Systems designed to support individuals in reaching engaging and self-actualizing experiences.

Flow: It is a positive, complex and highly structured state of deep involvement, absorption, and enjoyment. The basic feature of this experience is a dynamic equilibrium perceived between high environmental action opportunities (challenges) and adequate personal resources in facing them (skills). Additional characteristics are deep concentration, clear rules and unambiguous feedback from the task at hand, loss of reflective self-consciousness, control of one's actions and environment, alteration of temporal experience, and intrinsic motivation.

Hedonic Technologies: Mood-altering devices, which use ICTs to induce positive and pleasant experiences.

Positive Technology: It is an emergent field based on both theoretical and applied research, whose goal is to investigate how Information and Communication Technologies (ICTs) can be used to empower the quality of personal experience. Positive technology approach claims that technology can increase emotional, psychological and social well-being.

Social/Interpersonal Technologies: Technologies that seek to improve the connectedness between individuals, groups, and organizations.

Social Presence: The degree of salience of the other person in a mediated environment and the consequent salience of their interpersonal interaction. An individual is present within a group if he/she is able to put his/her own intentions (presence) into practice and to understand the intentions of the other group members (social presence).

Chapter 7
Towards a Flexible Cloud Education Environment:
A Framework for E-learning 3.0

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ABSTRACT

Web 2.0 tools offer innovative technologies for learning and training, and it exists a strong pedagogical foundation to include such tools in education. As a consequence of its more widespread usage arise issues in the context of managing these cloud services, such as to create adapted instances tool resources, to assign such resources to teachers and learners, and others. Web and educational interoperability technologies have provided initial paths toward building this type of e-Learning 3.0 cloud education environments, however, fundamental challenges remain such as granular tool resources management, and the lack of use of Semantic Web technologies to leverage automatic machine-processable tool API. To overcome these issues, an holistic model for flexible interoperability is contributed in this chapter. Covered aspects includes a semantic definition of tools' API, an interoperability service framework capable to automatically process APIs, a semantic proxy that enables usage of current APIs, and a system for learning activities orchestration using these tools. Furthermore, advanced semantic technologies to support the model for flexible interoperability are analyzed.

INTRODUCTION

Technology-enhanced learning has been a research area for many years that continues to evolve as new technologies enable new educational scenarios. *Tools and services* available on the Web allow learners and teachers to collaborate, communicate and share in new or enhanced ways has become popular as *Web 2.0 tools*. The term "Web 2.0" has been coined by (O'reilly, 2005). It indicates a shift towards a Web of tools and practices towards a more participatory Web to involve users more interactively. The tools offer mechanisms for sharing, collaborating, networking, content

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media production and others. Consequently, this has also initiated a new form of learning which might be called "e-Learning 3.0", and builds on the Web 2.0 concepts, tools, cultural and societal changes. This new learning approaches can make use of a holistic ecosystem that contains among others: new cloud infrastructures (for content, services and computing) (Chao, 2012), multiple devices (desktop, laptop, tablet, smart phone, gaming consoles, smart boards, smart TVs, others), augmented reality, geospatial information systems. Subsequently the educational process can be experienced by means of tools that can be accessed through a diversity of devices, places, contexts, thereby enabling those new interactions between participants (Cochrame, 2012).

The term *Cloud-Based Tools (CBTs)* is used interchangeably for Web 2.0 tools. CBTs that are designed:

For collaboration have the potential to engage students, by allowing them to interact and brainstorm solutions, elaborate reports, and create conceptual designs. This approach can inherently enable and facilitate both formal and informal learning. It also promotes the openness, sharing and reusability of learning resources on the web. (Mikroyannidis, 2012)

CBTs have the capability for interoperate with third party systems, therefore can leverage the services provided to orchestrate educational experiences, instead of the standard standalone view of a CBT, thus enabling the possibility to create a holistic e-Learning 3.0 ecosystem.

CBTs are constantly evolving. Many of the so-called CBTs have improved the cloud infrastructure landscape, with its Web interoperability capabilities. Through opening the CBT Web APIs (further referred as APIs) to permit Web clients to use their technology, thus fostering new, improved and creative usage of the CBT. API stands for *Application Program Interface*, which in simple terms can be referred as programmatic interfaces to control a CBT from another system such as a *Virtual Learning Environment* (VLE). This opens the possibility to create orchestrated services that provide more complex learning experiences, which were not possible before. Authors in (Hernández et al, 2013b) argues that

This also changes the paradigm from a monolithic architectural approach of education environments to a flexible, distributed and heterogeneous architectural setting for education environments, which is the aim of cloud education environments supporting teaching and learning activities. This also maximizes innovation potential, allowing interoperability of the best and most appropriate CBTs in the basis of learning needs, freeing up from a vendor specific approaches and limits, transforming the cloud education environment (CEE) into a digital educational ecosystem of services and resources available for the practitioners, in contrast to a large amount of not interoperable software services that are difficult to manage and organize for an educational setting. (Declan Dagger, 2007)

The *Cloud Education Environment (CEE)* paves the way for e-Learning 3.0. It augments any educational setting or system by exploiting as an ecosystem of applications, services, content providers, and computing power that does not belong to a particular educational institution. Therefore, this extends the range of possibilities to include many types of CBTs that can be used for educational objectives, some of them designed with that purpose and many others that might not be originally conceived for that but that will fit well for certain educational scenarios. The CEE has the potential to enable new educational scenarios while simultaneously fostering educational actions that bring new pathways for learning (Malik, 2009; Mikroyannidis, 2012). On the other hand, CBTs offer a diversity of rich

applications, features, and scenarios that can be used for education. Student-centered learning can be supported in the cloud (Chang & Guetl, 2010), as it promotes collaboration among students and instructors through setting a place to meet, interact, and conduct online learning activities using shared resources and processes (Berenfeld & Yazijian, 2010), while the cloud has been used to enhance higher education teaching and learning (Fox, 2009). In this light of this, a framework and architecture for an e-Learning 3.0 flexible CEE is proposed.

This chapter is organized as follows: first, in the background section it is initially presented an overview of technology enhanced learning and based on that the flexibility required to orchestrate learning with multiple CBTs. A summary of pedagogical gaps to support such flexibility is presented. Also as part of the background section a brief overview of interoperability technologies is introduced for both the Web in general and for educational settings specifically, which will serve as the technological foundation for further develop the e-Learning 3.0 framework. In the following section is developed the flexible CEE, which first presents a use case to simplify of the overall objective and benefits. Then summarizes the problems and challenges, the application scope, thereafter presents the main contribution of this chapter, a *model for flexible educational interoperability* to enable the e-Learning 3.0. This model includes a semantic definition for the CBT to be used, an interoperability service framework architecture that is capable of processing the semantic definitions of each CBT. Further, a semantic proxy has been designed, which permits enables the whole framework to interoperate with in current CBTs. The model covers the orchestration learning activities system that enables to deploy an e-Learning 3.0 experience. The section about future research directions will shed light into what is the state of the art on *practical* semantic technologies that can be used to assure the adoption of the model presented in this chapter. Finally, the conclusion section discusses aspects of advantages and issues of the whole framework and it provides final remarks on the future of e-Learning 3.0 frameworks and specifications.

BACKGROUND

Technology Enhanced Learning and Flexibility

The incorporation of CBTs in education appears to be one of the current important and, large steps in education. Many studies and use cases has been done. The learning theories categories such as *Associative*, *Cognitive* and *Situative* (Mayes & De Freitas, 2004) and pedagogical models support the inclusion of such tools (Conole & Alevizou, 2010), and learning activities can increasingly use them to foster engagement. Collaborative activities, new communication channels and, new ways to represent knowledge and express ideas, share information and have large audiences are part of today's educational environments on the Web (Conole & Alevizou, 2010). Social interactions change the way online classroom are perceived, and the teacher becomes more of a facilitator by intervening in the learning process; providing relevant, timely information; and constantly guiding learners through the learning experience.

Among the large diversity of learning theories, pedagogical approaches, models and frameworks, *Computer Supported Collaborative Learning,* CSCL (Dillenbourg, Järvelä, & Fischer, 2009) originally provided key concepts to understand and support such collaborative online learning experiences. In addition, moving from designing to orchestrating collaborative activities has several challenges, such as monitoring and adapting interactions, workload, coordinating interventions, internal and external regulation, social learning, and the continuous changes in the teacher's role

towards conducting a flexible learning experience. Thus, practical approaches for orchestrating learning where all of these components are aligned and creating synergy among them can enhance the path towards obtaining learning outcomes (Prieto, 2011). Flexible educational environments play an important role for adapting and controlling the learning process.

Practical experiences have revealed that collaboration per se does not provide learning outcomes. Thus, orchestrating collaborative learning experiences requires models and frameworks (Conole & Alevizou, 2010). Structured models and frameworks can be applied in the use of Web 2.0 for learning. One example is the 5-stage e-moderation model (Salmon, 2002), which has two fundamental ground stages for successful online learning (according to the model), first to use the educational environment along with the correct levels of motivation and, the second, online socialization. Both CSCL and the 5-stage e-moderation model support the inclusion of Web 2.0 into the educational process, and both will be taken into account when elaborating upon the educational to evaluate the technology outcomes of this work.

Although there are ever-increasing offers of CBTs, challenges to using them properly arise from pedagogical, methodological and infrastructure points of view. A comprehensive typology of Web 2.0 (Crook, 2008) provides CBTs categories: *Media sharing, Media manipulation, Conversational arenas, Online games and virtual worlds, Social networking, Blogging, Social bookmarking, Recommender systems, Collaborative writing,* and *Syndication*; this typology has served to identify the type of CBTs that will be used in this work: the *media sharing* type. A CEE can support any CBT, but the *media sharing* type introduces simple yet innovative features. Moreover, is required proper structured learning activities with their components (Conole & Alevizou, 2010): 1) the *context:* the intended learning outcomes and the environment where the learning activity takes place (aims, pre-requisites, skills, subject, environment, time, difficulty); 2) Educational approaches: Associative, cognitive, or situative); and 3) Task undertaken: This includes the type, technique, interaction, roles, resources, tools, assessment and sequence (Conole & Alevizou, 2010). Learning activities with the use of mediating artifacts such as: *Narratives and Case Studies, Lesson Plans, Templates and Wizards, Toolkits, Models and Patterns* (Conole & Alevizou, 2010), will result in a simple yet robust use case for CEE (presented in following section).

CBTs, such as mind maps, and online office productivity suites, provide flexibility to elaborate multiple types of learning activities. These tool types avoid the hurdles for most learners of first understanding a new technological tool concept, in order to later use it to express and acquire the learning outcomes. Nonetheless, the large ecosystem of CBTs (Chang & Guetl, 2007) implies that an online education environment needs to support such an ecosystem. Thus, in the introduced CEE concept, CBTs can be included not just by referencing, linking or launching such tools, but by enabling interoperability controls that allow the management of such a distributed learning environment. Therefore, the scope of this work is to enable a CEE that overcomes the inherent orchestration problems that multiple distributed CBTs have—such problems will be elaborated in the following section.

Finally, MOOCs present many of the same challenges of traditional online learning settings and bring new challenges, such as large drop-out numbers, along with raising new difficulties with enabling educational experiences in such a massive environment. Therefore, enabling the correct pedagogical structures and management controls is a key factor to enhance current practices in MOOCs(Conole & Alevizou, 2010).

The remainder of this section presents some of the current pedagogical gaps and challenges in education regarding the incorporation of such CBTs into education. Hence, *flexibility* is

required in educational environments, which in this research will be focused on the integration of a CBTs ecosystem (external tools to a VLE), and what management controls these tools provide to orchestrate them, in order to enable a CEE.

There are still many barriers when putting the use of CBTs into practice. One of them is knowledge expansion, which means that it is possible to use, remix and repurpose with the content. On the one hand, it may lead to more knowledge (Surowiecki, 2004); on the other hand, the knowledge may become superficial (Keen, 2007). Another issue is the absence of hierarchy and control, expressed in terms of increased complexity with the loss of content integrity and de-contextualized content, which may lead to misinterpretations. Boundaries are continually blurring, and different technologies and contents are continually overlapping. Some authors (Cardon, 2007) describe users' motivation to use CBTs as "hybrid motivations, where the individualisation of the user's goals meets the opportunity of sharing personal expression and the performance of creativity in a public space." Furthermore, all participants in this networked society are both individualists and, at the same time, mutually dependent (Ryberg, 2008). Finally, collective ownership and co-modification may become troublesome in an educational environment; therefore, CBTs may support non-formal and informal educational contexts better where the role boundaries between teachers and learners do not have to be well defined. Unless more clearly defined roles and the corresponding authority over the CBTs are added, it will be practically impossible to organize formal learning at an institutional scale. Thus, interoperability controls are required to support such roles and organization. In summary, the authors in (Conole & Alevizou, 2010) have summarized issues presented in Table 1, which presents the educational dilemmas of incorporating CBTs.

This diversity of changes implied by CBTs, from a pedagogical point of view, creates a barrier to adopting the changes. Among them are concerns of authority (especially related to how the learners behave in a digitally networked environment); computer literacy issues, such as if the newly introduced tools can be adequately used for education; the quality and effectiveness of their use; and the inherent issues with the legacy systems for long-term technological cohesion. All of these barriers can be decreased by having enhanced interoperability with CBTs, interoperability that enables control over and guidance regarding how the educational experience is going to happen, increasing the quality of the experience as a whole and lowering the literacy issues because the CBTs' management process and setup can be done automatically. Finally, simple yet comprehensive interoperability to support the aforementioned capabilities that can be used by other legacy systems, such as the current VLEs, is still a work in progress, as will be presented in the following Subsection. However, new Web technologies may smooth the path to enable more granular control over the whole educational experiences. Following are presented the current technologies to enable a CEE, including the current technological approximations to create CEE along with and overview of the interoperability underlying technologies to achieve an enhanced orchestration.

Table 1. Educational dilemmas arising as a consequence of new technologies

Cause	Education Dilemma
Expansive knowledge	Challenges the role of the teacher
Hierarchy and control less meaningful, content can be distributed and located in different ways	Need to rethink the design process, offers the potential for new learner pathways
Increasingly complex digital landscape	Widening skill gaps between the "tech savvy" and the others
Power of the collective, collective intelligence	Potential for new forms of learning; digital and networked literacies

Interoperability on the Web and Educational Interoperability

Enabling a CEE that integrates CBTs is indeed necessary for new educational experiences. The current ecosystem of CBTs and multiple content providers force educational practitioners to use a distributed digital environment in such a way that issues, related to content production, ownership, and authorship arise. Furthermore, it is necessary to provide a simple yet powerful unified environment that includes CBTs while addressing challenges such as simplifying the adoption barriers for teachers, giving them best practices, allowing them full control over the educational experience, creating easy initial steps for the use of a new tool for the learner, providing support structures for both learners and teachers, and allowing institutional adoption (Conole & Alevizou, 2010). Thus, issues such as hierarchy and control problems, role definition and corresponding management of those roles, authority over resources created, integration with legacy systems such as VLEs, and lower literacy issues are created when using a new CBT for the first time. Such a unified environment that addresses the described challenges and issues can only be conceived if granular controls for interoperability are enabled between a central management system (such as a VLE) and the CBTs. This requires access to the CBTs-APIs, and the focus of this chapter is to solve specific issues of control, management, and authority over this distributed ecosystem of tools. Currently, many approaches like the PLE widgets (Soylu, 2012) use a lightweight approach for interoperability, which enables CBTs in the educational environment but fails to ensure real integration with the API, thus limiting the educational scenarios. It also fails to address the current pedagogical needs mentioned in previous Subsection. The widget approach like ROLE (Mikroyannidis A. & Connolly T., 2012) claims to have a single entry point and a unified interface for enabling the CEE. This is partially true in that it does enable a single educational environment, but it does not offer a unified or guided educational experience, and it lacks granular controls over the tools that it integrates.

There are many educational standards and specifications, and according to Shepherd (2006), and AL-Smadi (2012), those can be organized as follows: Authentication, Content packaging, Data definitions, Data transport, Launch and track, Metadata, Philosophical. As of September 2014, the interoperability has many related standards or specifications, such as IMS Learning Information Services, the IMS Learning Tools Interoperability, the IMS Common Cartridge, IMS EDUPUB2, IMS Question and Test Interoperability, IMS Accessible Portable Item Protocol, IMS Learning Metrics Profile, SCORM, IEEE Learning Objects Metadata, IMS Learning Design, IMS Content packaging, and others.

The IMS LTI v.2.0 (IMS, 2010) is currently state-of-the-art in interoperability for educational settings, the objective is to enable Tool Consumers (TC) and Tool Providers (TP) to exchange information:

[IMS LTI v.2.0 specification] is essentially provided a means of connecting two systems together: a TP which 'consumes' the tool, and a TP which 'provides' the Tool to be used in the TC. A TC would typically be an LMS. Examples of TPs include an externally hosted testing system or servers containing externally hosted premium content. The nature of the relationship established between a TC and a TP via LTI is that the TP delegates responsibility for the authentication and authorization of users to the TC. The TC will provide the TP with data about the user, the user's current context and the user's role within that context. This data is provided in a secure manner so that the TC may trust its authenticity. (IMS, 2014)

Between the TC and TP can be to types of connections, one is LTI services and the other is messages. Messages are transported over HTTP usually to launch the TP. The LTI services is a

direct connection between the TC and TP using JSON-LD format (JSON-LD, 2013), the standard example given by LTI is that a TP will send back to the TC the grades obtained by the learners at the TP. As authors (Hernández et al., 2014) have identified:

The primary drawback of the current LTIv.2.0. is that it does not offer the concept of basic CRUD operations (create, read, update, delete) over the objects. Nor does it offer support for any other type of operation over an object. Thus, it limits itself to predefined communication between TC and TP without the ability to execute explicit operations that might be available on public API by the TP [in addition the] LTIv.2.0 does not use Linked Data for API description and discovery of properties and operations, nor does it have an ontology to describe those [IMS LTI v.2.0 it is limited to] an automatic contract process for the exchange of information.

When analyzing current educational interoperability specifications and systems, it is clear that they use a static standard contract-based approach for interoperability (system interfaces define how *contracts* have to be used, in which order, the dependencies between them and what the final results are that will be obtained (XML-RPC, n.d.), and the construction and maintenance of a CEE have a cost proportional to the number of CBTs to integrate. That is the case for the GLUE! System (Alario-Hoyos et al., 2013). Although it is argued to be loosely coupled because of the interoperability between CBTs and VLEs, it is not tightly constructed. Instead it uses GLUE! as an intermediary and still requires one to create custom programs for GLUE! interfaces connection to each CBT. So it is tightly integrated with GLUE! system instead of direct tight integration in each VLE. The same pattern of tight integration is followed by all *Block*-like solutions (GitHub, 2014) LMS Blackboard (Blackboard, 1997-2011), Moodle Blocks (Papaioannou, s.f.), Sakai Widgets (Desmet, 2008), LAMS Tool Adapters (LAMS, 2002-2009) and others, which are traditional APIs interacting with the VLE internals. These *Blocks* can host newly programmed contracts to interoperate with CBTs on a one-to-one basis. This static Web contract approach requires to create and maintain tightly coupled contracts between the CBT (TP) and the VLE (TC), so the creation and maintenance costs are proportional to the number of tools to integrate.

The Web is certainly not only limited to documents—it can represent any type of objects. Tim Berners-Lee already considered this in the original Web's proposal (Bernes-Lee, 1989); thus, the Word Wide Web Consortium (W3C) created the Resource Description Framework (RDF) (Swick, 1999). The Semantic Web is a web of data that can be processed by machines. The Semantic Web provides machine-readable data, as an extension of the Web. The RDF then defines a simple data model of triples, consisting of the subject, predicate and object. These triples are used to build a graph, and multiple graphs will form a dataset. The original semantic Web technologies do not require IRIs to be deferenceable (capable of being referenced) to change. As postulated by the Linked Data principles (Bernes-Lee, 1989): "a) Use URIs as names for things; b) Use HTTP URIs; then, persons can look for those names; c) When searching for an URI, provide useful information, using the standards (RDF, SPARQL); and d) Include links to other URIs, thus making it possible to discover more objects". Linked Data mainly requires Web developers to identify their objects and concepts through an IRI, and also distinguish between objects that are information (e.g., documents) and objects such as things.

Current educational interoperability specifications and systems discussed in this subsection lack the ability to clearly define for CBTs the *objects* and their corresponding *operations* and *properties*, therefore the management controls over CBTs are limited; as is determined from a pedagogical point of view, *granular controls* over CBTs are

required. Furthermore, those specifications and systems do not use current semantic technologies that are capable of enabling machine-processable definitions of APIs, which will simplify interoperability efforts. In the following section is introduced a semantic interoperability model to enable a flexible CEE with semantic definitions for machine-to-machine processing of semantically described APIs.

TOWARD A FLEXIBLE CLOUD EDUCATION ENVIRONMENT

An Use Case

In order to establish a better understanding, an illustrative use case is presented. It starts with a teacher who has designed a *learning activity* that consists in four simple steps: 1) research over a given topic, 2) do a summary of the research and present it in a document, 3) based on the summary make a mind map presenting the main ideas and how those are connected between them, 4) submit for grading both parts of the assignment.

For the summary document it is required to use the CBT Google Drive document editor (Drive, 2014), and for the mind map the CBT MindMeister (MindMeister, 2014) is used. The problem is that both CBTs requires learners to create by themselves their own accounts to login, and then find some way to share the work done within the CBTs. Learners might be able to share the results of their work using a link provided by the CBT or a downloadable version. This approach may lead to confusion of how to properly use the CBT. A better approach, however, is to have the VLE to automatically create the Google Drive document and MindMeister mind map, and assign a unique document and mind map for each learner (a document or mind map created in the CBT are referred as *object instance*). This can be achieved through enable Web interoperability between the VLE and the CBTs Web API.

The benefit of such interoperability approach is that is possible to create a *centralized automatic management of CBTs*, with the following key enhancements to the process: 1) ability to create, read, update and delete (CRUD) CBTs object instances, enabling *granular controls* over them; 2) manage permissions over object instances; 3) the VLE remains as object instance owner, therefore can track all changes over the object instance and manage it; 4) the user accounts are automatically created in the CBT and *single sing-on* solutions can be implemented to make transparent to move from the VLE to the CBT without input further credentials; 5) the automatic approach provides better scalability for management of hundreds or thousands of learners that are typical in a VLE used for higher education; 6) is possible to send data back and forth between CBTs. Other more extended uses cases supported are described in following paragraphs.

Group Work: share the *object instance* with a group of learners that have to collaborate for the assignment. It should be also possible to identify who has contributed what. In a document example the learners write and edit parts of the content, thus it is possible identify who has written what, the extent of the contribution, and other relevant data.

Learning Analytics: with available data from the CBT it is possible to determine learners' behavior, such as time spent on the CBT, number editions and *objects* added to the CBT, object analysis and other relevant data that the CBT may provide. In a mind map example all of this is represented on number ideas added to the map, type of ideas added (only text, with images, links, others), how complex and extensive is the mind map (how many connections and levels of ideas exists).

CBTs connected learning paths: in this scenario it is possible to select relevant data from one CBT and use it in the next CBT. For example, from a document is possible to select relevant titles, keywords or pieces of text, and send it to a mind map to automatically create ideas within it.

Furthermore, the finished mind map created by a group of learners could be shared in class discussion group that happens in Facebook.

With a large selection of available CBTs, the design of learning activity can be enriched, and thus might be more engaging. Although the complexity to orchestrate such CBTs in an orderly manner increases, therefore is required an interoperability approach between the VLE and the CBTs.

PROBLEMS AND CHALLENGES

Referring to the background section several challenges and problems were identified to enable a truly CEE. The gaps identified are summarized in four groups and discussed in the remainder of this section: 1) how to enable a flexible CEE; 2) how to use open APIs to create an enhanced educational orchestration; 3) the problems of current interoperability approaches; and 4) how to create an application domain type definition of a tool that can be interpreted at run time by the machine without human intervention.

Enable a Cloud Education Environment

Today many software tools are available for everyday life tasks. The apps for the mobile platforms, such as iOS (AppleApp, 2014) and Android (Google, 2014), have thousands of them available. In September 2014, data from AppBrain Stats revealed more than 1,300,000 applications for Android (AppBrain, 2014), and AboutTechnology reported similar numbers for the same month (Costello, 2014). There are also thousands of CBTs (Conole & Alevizou, 2010). Thousands of tools are traditionally available for desktop computing. In September 2014, data from MetroStore Scanner reported more than 170,000 applications (MetroStore, 2014). And other environments are also growing or consolidating their app ecosystem, such as smart TVs and gaming consoles. Current learners typically have multiple devices, use multiple apps through them, and now experiment with scenarios and applications that were neither available nor possible before this ecosystem was in place. In this current reality, the standard monolithic environment approach for VLE is still predominant in education. Thus, the challenge is a distributed, non-monolithic environment because is not possible to limit educational settings to just one environment. The aim is to create an educational environment based on a distributed set of services and contents available in the cloud of apps and devices. Along with fostering addressing challenges described such as adoption barriers for teachers, allow teachers full control over the educational practices that are created, simplify learners' use of CBTs, and make such a CEE institutionally used and adopted. Another benefit of using CBTs is that many of them are running over cloud computing, which is highly scalable in terms of computing to support thousands of active requests. All of this, in conjunction with the nature of a distributed environment for performing the learning experience, brings a highly scalable environment.

Enhanced Orchestration through Open APIs

Learning orchestration requires flexible educational environments where design and planning can be reflected in an educational workflow, this requires full administrative control over all the components of the educational experience. Learning orchestration also requires interventions, adaptation of the learning paths, scaffolding knowledge and experiences from one activity performed in a CBT to the next one.

For obtaining educational success when using CBTs is necessary to have *granular* management and setup controls to ensure smooth use of multiple CBTs. Issues such as hierarchy and control, role management, authority over CBTs and integration

with institutional systems such as VLEs need to be solved. These can be achieved by using CBTs' APIs to enable orchestration, which will be explained in the following sections.

A current trend is that many of the available CBT-APIs that TCs can use to manipulate them. Mashery API network provides a collection of more than 70 open services that offer APIs for different kind of tools (Dev, 2014). Such APIs allow a TC to perform different types of operations over the CBT. Operations such as creating an instance of the CBT, assigning that instance to a user, giving read and write permissions, creating objects within CBT instances, and reading data of what has been done with the CBT instance are now possible. Different CBT support different sets of possible operations; it is up to the TP to decide what to open through their API. It has been noted (Alario-Hoyos & Wilson, 2010) that the more mature and popular CBT usually have a more open and robust API in terms of quantity and quality of operations for manipulations of their CBT instances.

The Current Interoperability Model is a Static Standard Contract-based Approach

To interoperate with the CBTs' API, it is necessary to create in the TC a custom interface. The same approach is used in other specifications, such as IMS LTI v.2.0 (IMS, 2010) or the GLUE! System (Alario-Hoyos et al., 2013). The custom interface will request the published operations of the API, and it will process the payloads of those operations. This custom interface will be as large and complex as the CBTs' API is. The more operations the API permits, the larger the TC interface will need to be. This model also requires the inclusion of a new CBT; a new corresponding custom interface at the TC needs to be built. As a result, any change or update in the CBTs' API (TP) will represent that all custom interfaces for each one of the TPs at the TC will need to be updated, tested, and (once ready), deployed. This also has a collateral effect; during the update phase, some services may be unstable or unavailable, depending on how the TPs manage their update cycle. Maintenance of custom API interfaces has a h0igh cost in terms of time to build and update and human resources necessary to build them through a software engineer.

Application Domain Type Definition and Machine Processable APIs at Run Time

An application domain type definition is a generic description of an API for a given application domain. An application domain such as mind maps may have several company products or TPs with such a tool. Another example of an application domain is an online document editor, which already exists in many TPs that provide such a CBT. The application domain type definition is a generic and formal representation of the APIs for such CBT (e.g., mind maps), and this formal representation will have a description of the most common features that an application domain may support through its API. For example, a mind map CBT will have several TPs, those different TPs products can have very similar set of features, or different features. As a real example, the mind maps of MindMeister (MindMeister, 2014) are the traditional representations of such a tool, while the mind maps of Pearltrees (PearlTrees, 2014) are not the standard visual representations of a mind map—in essence, they are mind maps that could be used for that purpose. Thus, with the multitude of CBT available, there is no formal approach to describe an API, nor is it possible to define a common set of objects, operations, and properties for an application domain type (e.g., mind maps). It is necessary to formalize a specification of the application domain type.

This will identify that API1 operation 1 is the same as API2 operation 2. With this specification, is possible to design systems that can interoperate others by linking this generic semantics (the

application domain type definition) to the TP specific semantics exposed in their API. And moreover, it helps to specify what an application domain type should provide in its API, and with this information, the TC may choose what to support and include when considering the inclusion of an application domain type.

Still, there is no standard approach for machine-processable APIs at run time. How can we create such a definition of a CBT that can be interpreted at run time and avoid custom program interfaces for each new tool? A semantic approach for interoperability educational systems does not exist, although IMS LTI v.2 uses JSON-LD (JSON-LD, 2013), which can embed semantics, but it does not use these features at its full potential. A semantic approach will lead to the discovery and identification of the available objects, operations and properties a tool has—all at run time, and all machine-processable. This will clear the hurdles of custom interface programming for each tool. This improves the scalability of building, extending and maintaining tools.

Application Scope

Enabling a CEE has several applications that benefit the educational process. This includes process automation and educational orchestration to create completely new educational experiences. Following a list of the main applications identified for such e-Learning 3.0 environments:

1. Teachers are able to enable and orchestrate educational experiences using several tools with full granular control and management.
2. Teachers and learners are able to launch a given tool within their VLE and realize their learning experiences using those tools while interoperability with these tools is automatically orchestrated.
3. Orchestrate interoperability with CBT by automatically recognize and operate APIs.
4. CBT's API description is constructed at a higher level by semantically describe the objects, properties, operations and their relations, rather than writing standard contracts and requests.
5. Creating application domain–type specifications serve as a generic description of APIs.
6. TPs may choose to support partially or totally and/or extend such application domain–type specifications.
7. TCs are able to define which objects, operations and properties supported by the TP use.

Model for Flexible Educational Interoperability

The *model* that is presented in this Section, gives a solution to the problems and challenges within the application scope outlined in the previously. The *model* is a combination of an interoperability service framework that first defines a semantic vocabulary for representing the application domain type APIs, and how each specific tool implementer can use and customize it. The corresponding interoperability architecture to support such vocabularies includes machine-to-machine communication for automatic service recognition. Finally, an orchestration of services within the context of learning activities is presented, a piece of the solution that is highly relevant to enabling CEE experiences.

Sematic Definition for CBT-APIs

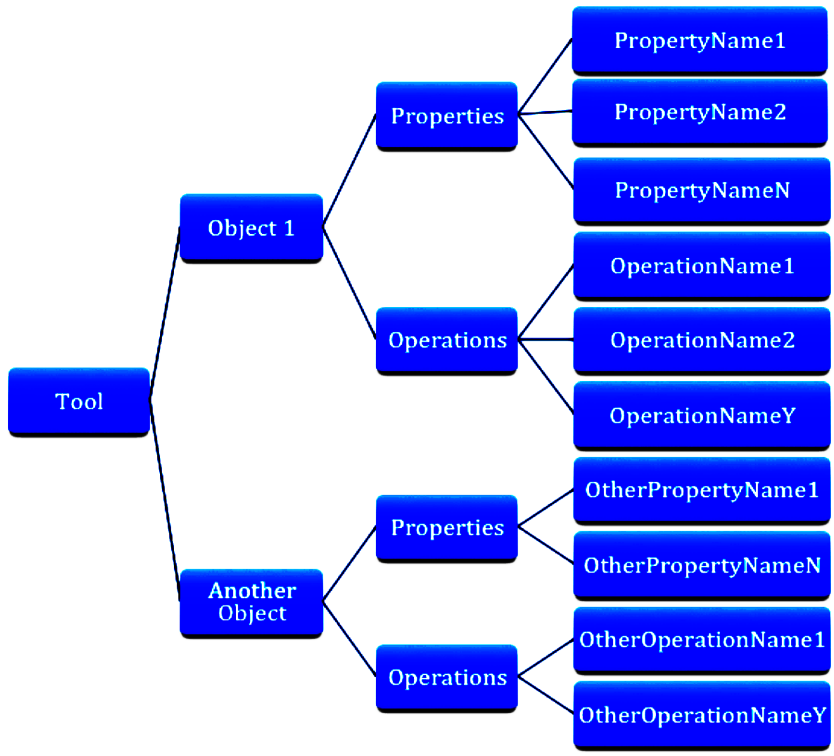
Improved support for interoperability of APIs needs to be provided based on the problems and challenges, and on the scope of this research. First, each available API method can be identified as an operation to an object or resource. An *object* can be anything within a given tool; it can also be the learner, the teacher, or a piece of the tool. For instance, if the tool is a story telling builder, then one story can be an object. Within the story can

be additional objects such as characters, stages, acts, etc. Each of those objects will have a set of *properties* that will help to describe and utilize it. As an example, the story object may have a set as properties such as a title, a description of the story, and the owner of the story. It may include a collection of acts related to the story and how they are going to be presented. Thus, it is possible to identify a given tool with objects, their properties, and how those objects are related. Additionally, actions can be performed on an object; these are called *operations*. Such operations could be performing a given act; this may imply running an animation that was built for that act. Figure 1 describes the schema of a tool with its objects and their correspondent properties and operations.

If this schema is used to identify all possible objects, properties and operations in an application domain type such as storytelling, it will be possible to come up with the characteristics that such an application should have, which can then be translated to an API. This can also be represented as an ontology. In the ontology, an object can have properties, and through those properties can link to another object. For instance, the learner could have multiple stories, and each story may contain multiple acts. This ontology could be used to identify the main objects, properties and operations an application should have for interoperability.

With the ontology that describes specific application domain type generics in a API, it is possible to create a generic vocabulary using semantic Web (e.g. Linked Data). The generic vocabulary will be used to model an application domain type (e.g., storytelling tools). The generic vocabulary will be useful to support basic definitions in a domain. For instance, a storytelling tool should have a basic number of objects such as learner, story and act. For each one, a set of properties could be defined. Over each object, an operation might be

Figure 1. A simple schema of a CBT with an object: Its properties and operations



performed. Once this definition is done, using a generic, then the TP will be able to reference to that generic vocabulary to describe its own tool API. The generic vocabulary (GV) can serve the TC to identify the application domain type and use the GV as a base for further interoperability with tools. The TC may choose to only accept providers that conform to the generic vocabulary, and those that do not won't be offered to learners. The TC may even choose which objects learners can manipulate and which properties learners can access. The TC may also choose to support extra features that the TP exposes, even if those features are not defined in the generic vocabulary. Having a generic vocabulary may help institutions, local organizations, state or province ministries, and governmental organizations to define what an application domain type should include. The TP may choose to adhere to that generic vocabulary by referencing it but not necessarily by changing its own API vocabularies.

Once the *generic vocabulary (GV)* is defined, it can be used for building the specific API vocabulary. The API vocabulary can be built using the GV. It will describe all the objects, properties and operations that are specific to a particular tool. Therefore, it is possible that a tool may have all the correspondent objects defined in the GV, but it might not have the same properties and operations over the objects. This hypothetic tool may also feature extra objects and corresponding operations. Following the storytelling example, the tool may have a character object that represents a character that will perform something within an act. The character object may have operations like initialize performance and others. This object might not be specified in the GV but supported by the tool, and thus specified in the API vocabulary. Then, the API vocabulary also will define the properties that the object has and the type for each property. This might be something that is already defined in the GV but overridden in the API vocabulary. For the operations within the API vocabulary, it will contain the specifics of what is expected such a property and what it will return, such a collection, a string, an object, what HTTP method it uses, and others. These elements are specific for each tool, therefore is not necessary to include it in the GV.

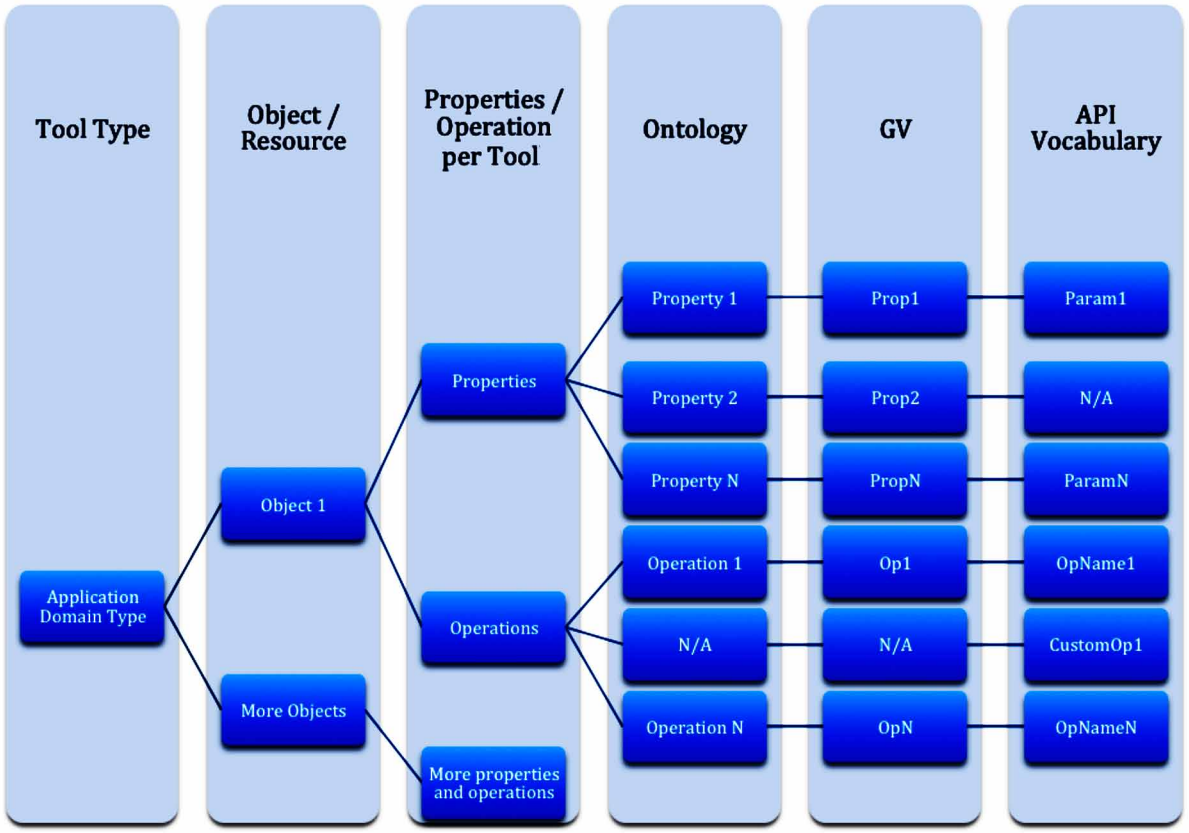
The concept of a GV has already been introduced, including how it will be used by the API vocabulary. The GV is built based on an ontology designed for it. In Figure 2 is an example of an object, property and operation mapping among the three. As it is depicted, one application domain type will have its own set of *standard and necessary* objects and properties, which will be represented in the ontology. Then those operations and properties usually have a one-to-one representation in the GV (both represent the generics in the tool domain). Then the API Doc may have all of those, partially support them, and/or include new ones.

Interoperability Service Framework Architecture

Now, With the defined vocabularies, both the generic and the specific per-tool (API Doc) vocabularies, it is possible to design an interoperability service framework architecture (ISFA) that is capable of interpreting these API vocabularies definitions and process them in run time with a generic processor. Therefore, it is not necessary to build a specific API programming interface for each tool, the semantics embedded using these vocabularies will be enough to search, discover and build communication, authentication, create requests, process responses, create user interfaces, and others, all of these happening automatically at run time. The designed ISFA interoperability process has four components:

1. Semantic Runtime Interpreter
2. Authentication Handler
3. Communication Service
4. Templating System

Figure 2. Example of relation between the Ontology, Generic Vocabulary, API Doc of a CBT from the object, property and operations perspective



A conceptual architecture of the four components is presented in Figure 3, and Figure 4 outlined the architecture-specific components.

Semantic Run Time Interpreter

This is the core of the ISFA. It will feature a *service processor* with the capability to analyze an API vocabulary and the GV and understand the CBT-API automatically at run time, including what objects, operations and properties are available and how they are related to each other. With this processed information, it is possible to create the business logic components exposed by the TP semantic API. In this architecture, following the current trend in composing multiple services, a current common approach to invoke a service is through the use of program utilities that can be invoked in a Web environment; thus, a widget approach is utilized (Olmedilla, Saito, & Simon, 2006), as other architectures have chosen to integrate with third-party TPs. In the ISFA, this approach is materialized by creating an *embeddable API* that can be invoked through a browser, but also with an independent execution program. This *embeddable API* should encapsulate and represent all the business logic identified by the *service processor.* Once this is available, it can be used within a browser as with a widget implementation, or in a particular system execution, as a third-party library to be invoked.

Figure 3. Interoperability service framework architecture (ISFA) interoperability process

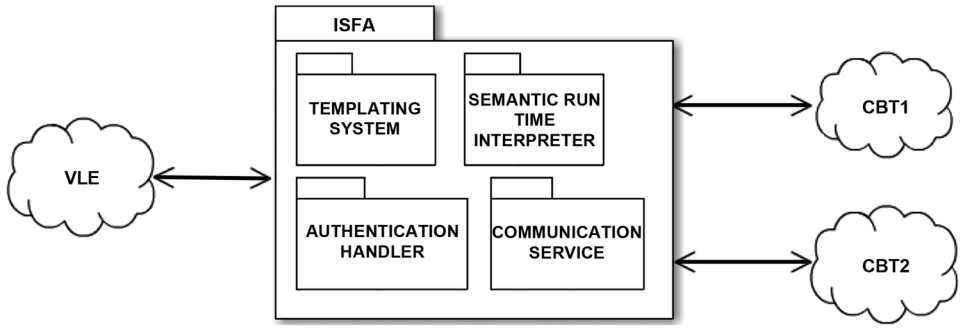
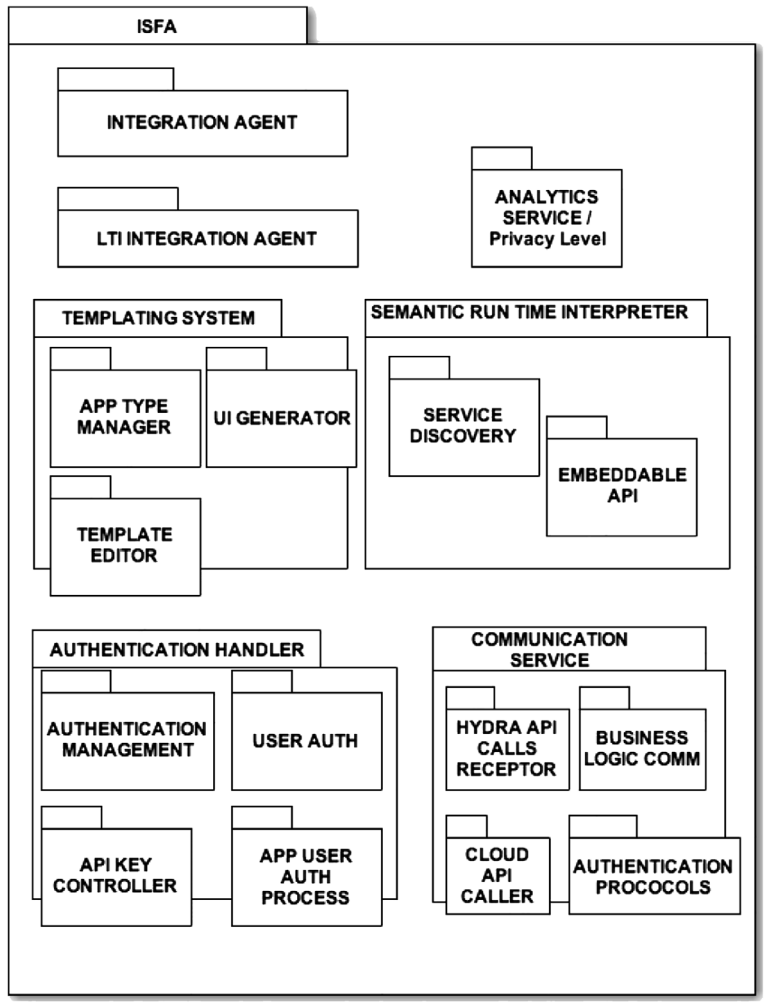


Figure 4. Interoperability service framework architecture (ISFA) components



Authentication Handler

Every TP will have an authentication protocol in place, whether it is a custom process or it is based on a standard or specification. In this ISFA, is avoided to impose a specific authentication mechanism, such as the OAuth 2.0 authorization framework (IETF, 2012) that is token-based. Nevertheless, support for multiple specifications might be needed; and, as interoperability experience has demonstrated, any specification implementation by a TP may contain specific tweaks that may require customization. Therefore, an *authentication management* needs to be in place to be able to define multiple protocols; this may include invoking a *user authentication*, which may require an *application user authentication process*, something that happens on the TP side. Also, it is common nowadays that an available TP API requires the TC to identify itself before initiating communication. This usually means that the TP will give the TC an *API* key that will be used prior to any communication by the TC.

Communication Service

This service will include support for requests and response processing from the TP semantic API. It is a centralized process, with a single point for communication back and forth between the TP and TC, in order to maintain authentication integrity with cross-domain issues (Armbrust, 2010). Also, it will be linked to the authentication protocols and inject the necessary information into the request to keep authentication in place in a REST architectural style for web services (Fielding, 2000).

Templating System

The main functionality of this system will be a *UI generator* that will automatically create the UI, materialized as web forms, of the objects, its properties and corresponding operations. Thus, an object will have a web form with all the properties as field entries, and operation over that object may allow the editing of object properties. This will use the *service discovery* described in the *semantic run time interpreter* to automatically create such a web form, and will use the *embeddable API* for enabling the web form to interoperate with the TP. A *template editor* will allow the enabling and/or disabling of objects, properties and operations for different user types, which means that the TP may expect a property and the TC may send it automatically without requesting a user input. For example, if the property is an ID for the object, the TC chooses not to request the user to input that ID and, instead, generates it automatically. Also, the *template editor* is capable of basic placement and style of Web form elements (through CCS3) to provide a more consistent UI, independently of which TP is instantiated for use.

Related to the above is the *application type manager*, which will present how each TP is supporting the GV, and it will allow administrator to configure whether to allow or not to use TP additional features, or even limit GV features, for all TPs or on a TP-by-TP basis.

Other Services

It is important to notice that, with the ISFA, it will be possible to use the *application templates* and *embeddable API*, as can be done in any other system, such as a VLE. The *integration agent* will act as a simple, yet highly secure, authentication mechanism between the ISFA and the VLE.

Other module service will be the *analytics service*, which will store relevant learning analytics data for further processing. This may include privacy-level management. The *analytics service* implies that the TP semantic API will provide such data. Finally, although is out of the scope of this research, the ISFA could have a built-in bridge to IMS LTI, thus leveraging its capabilities, such as group and user management, among others.

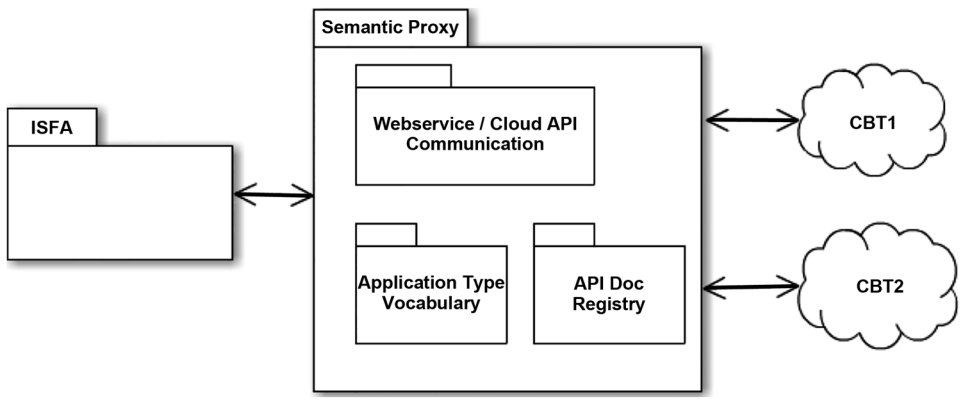
The Semantic Proxy

The ISFA interoperability process, depicted in Figure 5, takes into account that the CBT-API is capable of responding using a semantic technology, it uses a generic vocabulary, and has its own corresponding API vocabulary. But the current reality is, as of 2014, barely few CBTs uses semantic technologies. In the near future, the CBTs API is expected to remain as is, and the probability of short-term adoption of semantics vocabulary as payload is very small. Then, to support the ISFA interoperability process, it will be necessary to have a *semantic proxy* to handle requests and responses that goes back and forth between the ISFA and the current CBT's API. Therefore the semantic proxy is an intermediary layer as presented in Figure 5.

The semantic proxy will, first, get the entire request set from the ISFA and map them directly to the corresponding API method of the CBT. For instance, the ISFA may request an operation and will send the corresponding data with it, then the semantic proxy will recognize that request, and map that operation to the corresponding method exposed in the CBT's current API (that does not support a semantic approach, but may support REST, JSON, XML, SOAP, etc.). Once the CBT returns the payload in any applicable format, the semantic proxy will be able to process that response; and, with its content, construct a payload using semantics that will be processable by the ISFA. That is the main and simple purpose of the semantic proxy, yet it is a key piece in this design until semantic technology is widely adopted by TPs. The semantic proxy also needs to support a standard definition to map operations and properties over the API and its corresponding singularities. This includes proper management of extra properties that may be needed in the back-and-forth communication. Also, the proxy needs to support different type of payloads, communication protocols, etc.

It will feature a way to register new APIs; first, a *service designer* will have a generic vocabulary for the application domain type in place. Then, the *service designer* will create the specific API vocabulary for the new CBT-API to support. This API vocabulary will match with the available methods on the current CBT-API. Once the API vocabulary is defined, a *formal mapping description* will be created to match API vocabulary definitions to CBT-API methods; this includes authentication type, method URI, response format, response object and properties, error codes, etc., each with its corresponding mapping to the API vocabulary. This *formal mapping description* may be done manually or with a user interface.

Figure 5. Semantic proxy enabling communication between ISFA and the CBTs

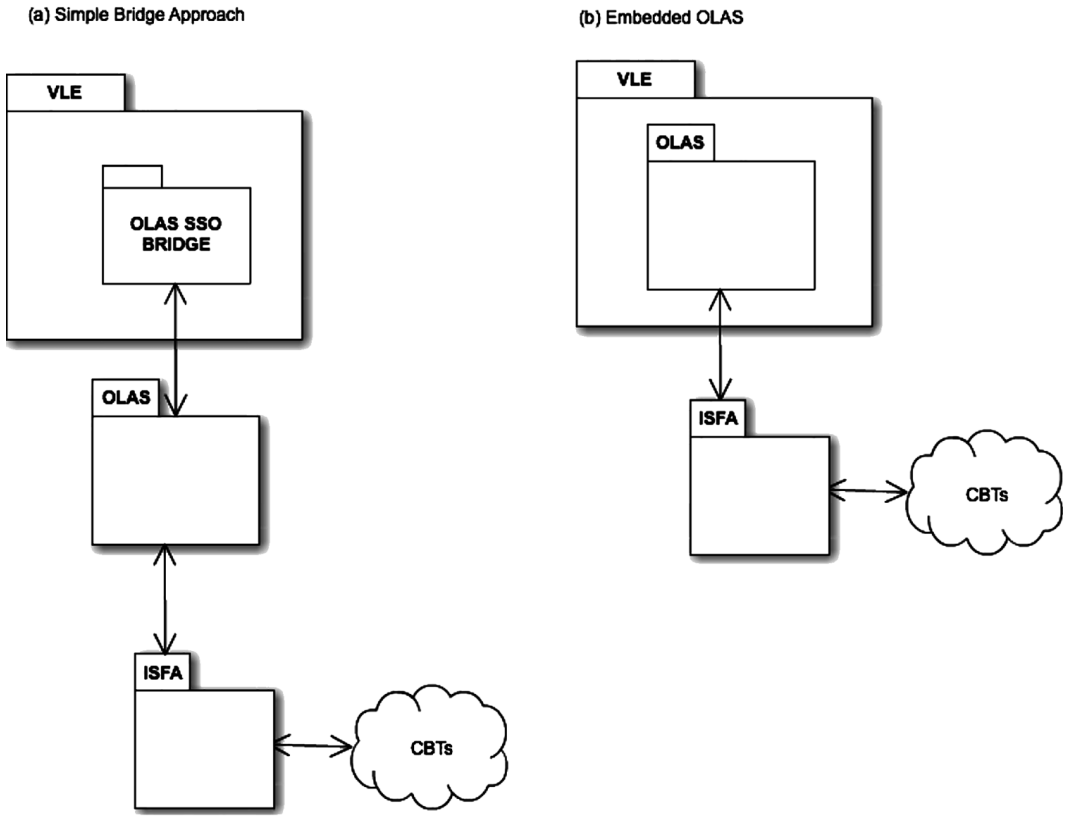


Orchestration Learning Activities System

In order to create CEEs using CBTs through the Interoperability Service Framework Architecture (ISFA), an *Orchestration Learning Activities System (OLAS)* has been designed, which will easily enable the use, configuration, management and integration of the CBTs available. The OLAS will be an interdependent system, which will work between the VLE and the ISFA to enable the usage of CBTs for education in the context of a learning activity.

Figure 6 depicts how the OLAS works along with the VLE, whether the VLE is a PLE, LMS, LCMS, etc. The OLAS will launch the TPs through the ISFA. First, it will act as the user interface for educational settings of the ISFA by providing templates of the integrated CBTs. This is a lightweight system or package within a VLE, as in Figure 6 (a). The approach is that the VLE contains a simple bridge to send teachers and learners from the VLE to the OLAS standalone system, where the learning activity using the CBTs will be configured, performed and delivered. In this case, within the VLE will exist only a native package implementation sending back-and-forth single sign-on (SSO) user credential authentication and corresponding data that needs to be exchanged, such as user and group information, results from activities, etc. For option (b), the OLAS does not run as a stand-alone system, but it does run within the VLE as a native package. This will lead to simplified communication between the OLAS package and the rest of the VLE, and it will not require a SSO. Both options (a) and (b) will have

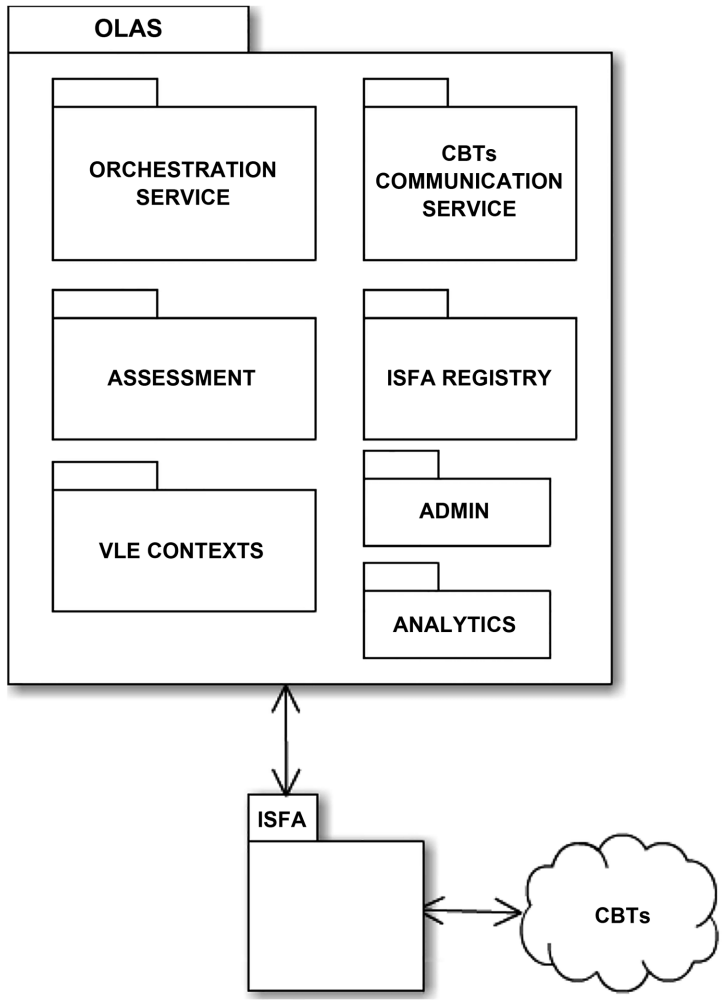
Figure 6. The VLE and OLAS integration approaches



the same set of functionalities, but option (a) will require a lightweight integration to the VLE, enabling faster adoption by VLE products and easy maintenance. But it will require the setup of another system, the OLAS, and thus will support its deployment. Also, it will not have user interface space constraints because it only displays itself. In option (b), the OLAS will run within the VLE and thus is expected to present its interface within an already-created layout or template (e.g., a block in Moodle, a portlet in .LRN or a widget), thus limiting the available space, which is important when launching the TPs' interfaces. It is possible to overcome that trouble by adding a modal view that can use the full space available without constraints, such as dealing with CSS, or by simply opening a new browser window. The (b) approach will require a larger custom package construction for each VLE to enable it, as it will require native framework programming, database management, etc. User and group context will be native for this approach. Both of the approaches will be plausible; for this research, we have chosen the (b) solution because it requires less custom programming for each VLE to integrate with.

The OLAS modules are represented in the Figure 7. First, OLAS has an *orchestration service* that will provide the creation of learning activi-

Figure 7. The Orchestration Learning Activities System (OLAS) Architecture



ties and the corresponding CBTs' objects that are present within the educational context grouping, such as class, group class, or individual assignments, which are known as *VLE contexts*. In an OLAS learning activity, it is possible to create CBT instance objects for the learners to work with, and those instances can be a copy of a CBT instance already created, which therefore acts as a template for other instances. For example, it is possible to create a document with a given index to be filled out by the learner or a mind map with the main ideas to be extended. Also, it enables the user to automatically manage CBT instance creation. An instance in this case would be the object that would be given to the learner to work with—for example, a mind map object created only for an individual learner. Each learner in a learning activity may have his or her own mind map to work with. This will involve creating the object instance and assigning the proper *editor* permissions. This may also extend to revoking permissions and giving a *read*-only permission, which is suitable in the event that the learning activity's due date has already passed and therefore the learner cannot longer modify the object instance and can only view it.

The OLAS has the capability to create learning activities that are composed of using multiple CBTs (e.g., first make a summary in an online document, then extract main ideas into a mind map and finally represent it using a storytelling tool). These CBTs' orchestrations may include communication between them; thus, they require a *CBTs' communication service*, such as the interwidget communication like in the known examples in a PLE (Hernández et al., 2013c). This will help to automate the information back and forth between CBTs, for instance, from the previous example, extracting titles from a document to automatically create a mind map of ideas. Then, from the mind map structure, the user can create a corresponding structure using storytelling tools, such as acts and scenes.

The OLAS includes the association of teachers and learners, enabling a common environment to perform and access the learning activities. Once a given learning activity piece has been designed, the system allows the teacher to deliver it to the learners.

Once the learner has completed the learning activity, the OLAS connection results from the learning activities to the VLE assignments and/or gradebook solution (or other correspondent control system that requires such an input for further grading), thereby sending results from the CBTs directly to the VLE. The results may be in a format that needs to be assessed (e.g., a mind map tool will deliver a mind map instance that has been assigned to a student or group of students, and this mind map will then be assessed and graded by the teacher, a teacher assistant or a similar person using a manual process). Or it is possible to send the current grade obtained by performing a practice in a CBT, which may have an automatic grading process. All this process may include the launch of corresponding *assessment* methods available in the VLE, CBTs and/or third-party systems.

The aim with the OLAS is to be simple and flexible enough to not impose any pedagogical or methodological paradigm, approach or model because the purpose is to create a workspace environment to use CBTs for learners and teachers, rather than leaning toward pedagogy.

Although many systems for learning activities management already exist and have a prominent specification, such as the IMS Learning Design (IMS, 2003), it is out of the scope of this research to use them because it would require possible extensive adaptations to the systems or the building of new layers. Therefore, is proposed a simple yet powerful interface to use in conjunction with the ISFA. The OLAS enables simple workflow management with simple thresholds in this case represented by a quantitative indicator that must be met before allowing the learner the go to

the next step of the workflow (e.g., a minimum number of ideas in a map or a minimum length of a document counted in number of words). These workflow thresholds can be obtained and calculated from CBT-API.

There is an *administration* interface for VLE managers to configure what CBTs services and capabilities will be enabled. Such configurations are provided and stored in the ISFA but accessed via OLAS. One of the final features is to enable a bridge to better capture *analytics*, especially user behavior within the OLAS user interface. To use the ISFA, the OLAS is required to have an *ISFA registry* that will identify and authenticate the use of the ISFA. This emulates the *API key* for a TC to a TP.

FUTURE RESEARCH DIRECTIONS

It is necessary to select a interoperability Semantic Web approach to create the proposed *model*, and such technologies are leaning towards Linked Data as seen in the background section. Therefore, to realize a flexible cloud education environment, is necessary to select a technology that implements Linked Data and at the same time provides a practical approach for developers. A successful and recent implementation of Linked Data is JSON-LD (JSON-LD, 2013), whichis a very popular serialization format, while JSON-LD supports transporting Linked Data using JSON. The initial goal is to make it easy to developers to use it by transforming their current JSON to JSON-LD (both are fully compatible). Moreover RDF has no inherent support for hypermedia, so a shared vocabulary to support the concepts that are usually found in APIs is needed, including full support of RESTful principles; the *Representational State Transfer* (REST) allows the creation of extensible, evolvable, maintainable and loosely-coupled distributed systems in the Internet (Fielding, 2000). This will allow generic clients to describe and process a given API. For simplicity, a RESTful API includes interlinked objects, each identified by an IRI (M. Duerst, 2005). A client will need to understand the semantics of a hyperlink (e.g., the relations between objects). The Hypermedia-driven applications (Hydra) vocabulary serves to describe APIs using JSON-LD that are truly RESTful. According to Hydra's draft, the basic idea:

[…] is to provide a vocabulary which enables a server to advertise valid state transitions to a client. A client can then use this information to construct HTTP requests which modify the server's state so that a certain desired goal is achieved. Since all the information about the valid state transitions is exchanged in a machine-processable way at runtime instead of being hardcoded into the client at design time, clients can be decoupled from the server and adapt to changes more easily. (Lanthaler & Gütl, 2013)

JSON itself is a widely used payload format thus is quite straightforward to further adoption of the proposed solution. Many TPs already have JSON payload, then they will be able to adopt JSON-LD without too many changes over their existing API. Furthermore RESTful services are a highly common in APIs, thus supporting them correctly is necessary. Hydra is a small addition to the current APIs, to describe it semantically using Linked Data and with a robust REST implementation. This is a powerful mechanism that will enable discovery at run time of the API. Hydra provides the possibility to create generic descriptions of an application domain type, highly relevant for this research to support the semantic model. Moreover it provides de flexibility for the TPs support their own set of objects, operations and properties, a prerequisite to the flexible interoperability model.

Using Hydra vocabulary it is possible to create self-descriptive, hypermedia-driven APIs. They can fully use Linked Data expressivity with REST's major benefits, such as scalability, evolution, and loose coupling. Hydra models represent objects, properties, and operations, among other

useful classes for describing APIs. Hydra can also support the creation of a generic vocabulary, which formed with subclasses of Hydra classes, and can model a specific application type domain (i.e., a mind map generic vocabulary can be used as a basis to model any mind map tool API). These generic vocabularies can be built based on corresponding ontologies.

This review determines that due to the current state of semantic technologies, one of the best options when using semantics is through Linked Data, and strong options are JSON-LD and Hydra. The first is a well-known serialization format, which will ease adoption of developers of Linked Data. The second is a simple yet complete vocabulary that is capable of describing an API. Hydra enables full API description and discovery, which could potentially decrease the interoperability costs for a CEE, because interoperability happens at a higher and simpler abstraction level. The costs are expressed in terms of time to construct and maintain interoperability with the APIs. In a CEE, it becomes even more important to reduce costs because potentially it could have large and evolving tools to interoperate with. If a semantic approach is going to be used to create interoperability with CBT-APIs, it will be necessary to have a semantic vocabulary that is capable of describing such APIs, so it is a matter of using something such as Hydra or creating one for this specific interoperability scenario. The later approach will have the additional requirement of creating generic parsers for such a vocabulary. Hydra provides such a basic vocabulary processor.

CONCLUSION

The learner's experience can benefit from *flexible CEEs* by introducing innovative learning activities that use CBTs. It enables new educational experiences that were not possible before with a monolithic VLE approach (addressing challenge *to enable a CEE*). This includes for MOOC settings that the technical deployment is easier, the inclusion of new CBT is simpler, and the scalability to use and orchestrate those CBT with hundreds of thousands of learners can be successful and manageable. The presented model simplifies interoperability for education and allows access to the complete set of features offered by the API. Thus, it permits teachers and learners to create tailored learning experiences and utilize VLE management controls that are not currently available, as described in the use case. With this interoperability approach, it is possible to enable learning orchestration mechanisms (Hernández et al., 2013c; Hernández et al., 2013a; Hernández et al., 2014) that can enhance the learner experience through the use of CBTs (meeting challenge of *enhanced orchestration through Open APIs*).

Currently, to enable interoperability between a VLE and CBTs API, custom-made interfaces for each tool are required to be integrated; that requires programming interfaces of each API which implies a considerable effort and costs to build and update each interface. The presented solution enhances that approach, as it converts APIs into APIs powered by semantic technologies. The model describes a robust way for the TC to control and administer tool objects, defining its properties and possible operations. At the same time, it simplifies interoperability efforts, by enabling a general abstraction for an application domain type (e.g., a mind map) through the generic vocabulary and permits the tool to be discoverable. For example to find all operations available for a tool at run time without the customized code per tool involved. And it is the APIs' discoverability that reduces the necessary effort and costs to deploy it. Instead of manually coding programs contracts between the TC and TP, it is just a matter of defining the tool API as described in this chapter (this discoverability overcomes the challenge of *the static contracts* and enables *the machine processable APIs*).

A large majority of CBTs do not use semantic annotations yet. Consequently, there is a need to

create an intermediate stage. Once the intermediary component is in place (semantic proxy), a TC that is capable of using semantics will be able to consume any current API. The ISFA will be able to automatically process any CBT semantic API through its semantic run-time interpreter, and it will then provide the necessary controls for the VLE and the OLAS to manage and orchestrate educational experiences. All authentications will be handled as well by ISFA both at the user and application-to-application level. Then, the OLAS, by using ISFA for interoperability, will enable the creation and orchestration of learning activities, therefore the use case is fully supported.

There are many types of CBTs, which can be grouped in *application domain types* (refers to a given type of tool, such as to all TPs that have the mind maps functionality). Currently is required an extensive review of several classified CBT-APIs for each *application domain type*. For each type can be designed an ontology to formally describe the semantic definition for interoperability with CBT-APIs.

Regarding development cost, for TP developers to adopt this technology will require to implement their already available technologies using some extra description semantics, something that happens at a higher level of abstraction compared to coding software that deals with every implementation detail, thus presenting a straightforward path for adoption. And for TC is all about automatic interoperability, and then manage a layout level the interface and/or build workflows for the desired behaviors by using the ISFA. Whether the developers adopt the semantic approach and technologies is something that remains to be seen. One final word about the ISFA, it is modeled to work standalone, therefore is an open path to integrate it with any VLE, or with other educational editors, such as IMS-LD based editor. It remains as an open issue how to merge this semantic model and its corresponding vocabularies, ontologies, etc. with IMS LTI v.2.0. The objective of that merge will be to avoid duplicated solutions provided between this model and LTI, in areas such as authentication, group contexts, learner profiling, etc.

Finally, further studies about learning activities using CBTs need to be performed, especially in the areas of motivation, emotions, usability and from the pedagogical perspective. These studies, along with gathering information from learners' behavior in an exemplarily orchestrated ecosystem are the keys to deeply understanding an e-Learning 3.0 CEE and its impact on education.

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KEY TERMS AND DEFINITIONS

Cloud-Based Tools: Web 2.0 tools that have its own open API access and run under cloud-computing infrastructure.

Cloud Education Environment: An educational environment such as a learning management system that integrates the use of cloud-based tools.

Flexible Interoperability: Semantic Web based interoperability approach that automatically discovers and adapts to APIs.

Granular Controls: Ability to describe each tool API at the object level, including properties description and available operations.

Machine Processable API: Capability to process an API based on a semantic description. The description forms a graph of resources (or objects), its properties and corresponding operations, thus is self-discoverable.

Semantic Generic Vocabulary for API: A generic description of a API application domain tool, which can be used as a base to describe a specific tool.

Static Web Contracts: Standard API calls, traditionally coded based on API description. Static contracts are hard-coded programs requests to API, which will need to be updated if the API changes.

Chapter 8
Methodology Applied Problem-Based Learning in Teaching HCI:
A Case Study in Usability Evaluation of an Online Course

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ABSTRACT

Problem-based Learning (PBL) is an instructional approach that uses a real problem to focus, motivate and facilitate learning relevant to the future performance of student conceptual, procedural and attitudinal knowledge as professional life. This paper presents and discusses the implementation of PBL teaching model in Human Computer Interaction (HCI), specifically in teaching usability evaluation of an online course. The model was applied to three classes of the HCI course, involving 16 students, a Brazilian University and 82 users. The methodology and results are presented in this work.

INTRODUCTION

The relevant changes in the society, provided by technological development and improvements in the educational process, are mainly reflected in the actions of teachers in the academic context. Educators are often looking for better ways to promote learning, either through changes in educational projects, either by adopting new teaching strategies (Kolmos, 2012).

Problem-Based Learning (PBL) is an instructional approach that has been experienced since the 60s, bringing significant results, impacting on the motivation of students and improving the quality of education (Savery, 2006), (Polyzois et al., 2010). In this approach, students work in small groups, researching and solving complex and practical problems of daily life (Loyens et al., 2011). A feature of these experiments is that the student becomes a more active role in the teaching and learning process, while it is the role of the teacher advisor of studies.

One possible way to use the process of teaching and learning based on PBL is through projects

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conceived as strategies for building knowledge. This method can motivate students and increase their productivity (Moylan, 2008). Therefore, it is necessary to create an action plan that allows performing the division of labor among students to enable achieving partial goals that will lead to the solution of the problem.

From real problems and based on an action plan that contributes to the understanding of the problem and its solution, PBL aims to join theory and practice (Savery, 2006). The application of PBL, through projects, can help develop work-related skills in staff, reflection and decision making.

There is debate about problems of the current model of professional training in teaching Engineering. The main complains are the indifference and apathy of the students in the classroom and the lack of initiative and inappropriate professional behavior of graduates (Case & Light, 2011). School curriculum of these courses is also organized sequentially, where theory always precedes practice. And the practice exists only when there are lab classes, workshops, group tasks, teamwork inside and outside the school environment, technical visits and project development. These activities tend to be naturally participatory and promote student involvement in the learning process. However, still dominates the pedagogical challenge of incorporating active practices in space and time currently occupied by traditional lectures. It is in the classroom and in the relationship between teacher and student that the changes are most needed.

There are many methods of teaching and learning that can contribute to a more effective learning. In a way, all forms of active and collaborative learning, student-centered, and constructivist teaching methods comply with this purpose. Among these method concepts, skills and attitudes in the curricular context and in the classrooms, we highlight the PBL, which is recognized for its ability to work simultaneously.

Research shows that PBL is a very effective teaching strategy, regardless of the subject, when compared with traditional teaching methods such as lecture. Students assimilate greater volume of content, retain information longer and enjoying their classes with more satisfaction and pleasure (Kolmos, 2012). Students who experience this method gain more confidence in their decisions and application of knowledge in practical situations, improve relationships with colleagues, learn to express themselves better orally and in writing, acquire pleasure to solve problems and experience situations that require taking decisions on their own, reinforcing the autonomy to think and act (Kolmos, 2012). PBL seems to be advantageous compared with expository instructional approaches; it is possible to contemplate the alternative of combining lectures with work problems. The motivation for developing this chapter was to understand the effects of this teaching methodology in Human-Computer Interaction (HCI) courses, specifically in the usability evaluation of interactive systems. The usability evaluation aims to assess the quality of the interface as a tool able to provide improved user-computer interaction. Different types of evaluation, with own goals and characteristics can be used (Nielsen, 1990; Nielsen, 1994; Nielsen 2012; Tselios, et al., 2008). In this chapter two usability studies are presented: User testing and heuristic evaluation through inspection. Both studies were conducted from the perspective of PBL methodology.

This chapter is organized as follow. This introductory section sought to trace the relevance and justification of the research, a second section is to review the literature on two topics of interest: usability evaluations and Problem-Based Learning. In addition, the chapter presents a discussion of the challenges in engineering education, explaining how PBL can motivate students of these courses and then presents a study on the related work involving PBL in teaching Architecture, Engineering and Computing, particularly in the disciplines of HCI. A third section presents a case study of the use of PBL in teaching HCI, the methodology adopted, the system used in usability evaluation

and the application of the PBL method to teach HCI. The following section seeks to discuss the discoveries of this research. And one last section is reserved to the considerations and conclusions of the study.

BACKGROUND

To facilitate the understanding of the project presented in this chapter, it is necessary to address issues related to usability and PBL, as well as presenting research papers related to this chapter.

Usability

Several definitions of usability are proposed in the literature, the most used one provided by ISO 9241-11 (1998): usability is the ability of an interactive system offers its user in a given context of operation, to perform tasks, effectively (which is the accuracy and completeness with which users can achieve their goals), efficient (that is the relation between the accuracy and completeness with which users achieve certain goals and resources spent to achieve them) and satisfactory (which is the comfort and positive attitudes of the users regarding the use of the system).

As for Lauesen (2005), Avouris (2001), and Nielsen (1990, 1994), usability consists of factors such as: a) Easy learning: how easy is the learning about the system for several user groups; b) Efficient: the goal is achieved through the system by a frequent user; c) subjective user satisfaction; d) Understanding: how easy it is to understand what the system runs; e) Adaptation to specific design standards interfaces; f) Adaptation of the system in terms of user experience, which can vary between beginner, intermediate and advanced.

A systematic evaluation of user interfaces is an expensive process because it must involve a statistically significant number of experiments with typical users in laboratories specially built for this purpose (Nielsen, 2003). According to Sommerville (2001) working on this proportion may not be economically feasible for small systems developed by organizations with limited resources, such as the APICE platform presented in this work. In this context, one can also involve other valuation techniques, such as inspection of usability, offering usability information extracted in a more quickly and economically way. The assessment methods chosen for this project, according to Nielsen (2012), are:

- **Inspection Usability:** Does not involve users and can be applied at any stage of a system development, being implemented or not, accelerating the project (Nielsen, 1994). It is performed by specialists and consists of, according to established criteria, examine the interface of one seeking to verify if it meets the requirements of system usability. In addition to finding problems, it is necessary to quantify their severity: more severe problems should be treated with higher priority than less important problems (Nielsen, 1994). The problems can be classified as follows: 0 - is not necessarily an error of usability; 1 - Problem aesthetic; 2 - Low priority; 3 - High Priority; 4 - Catastrophe: must be corrected immediately
- **Usability Testing:** Necessarily involves users and includes experimental and empirical methods, observational methods and questioning techniques. In this case, it is necessary that the system has some real implementation (Rubin, Chisnell; 2008).

Problem-Based Learning (PBL)

The Problem-Based Learning (PBL) is a learning theory in which students learn through solving a problem. The origin of the methodology of PBL dates from early last century, when the American philosopher John Dewey proved the "learn by doing" (Dewey, 1910). Dewey wanted to use a stu-

dent's ability to think, gradually, in the acquisition of knowledge relative to solve real life problems.

The PBL methodology is based on educational principles and search results in cognitive science, which show that learning is not a process of passive reception and accumulation of information, but construction of knowledge (Savery, 2006). For this information to become known it is necessary to activate cognitive structures and concepts about a subject and allow students to develop and assign new meanings.

In PBL, the facilitator's role is to guide students in the learning process, identifying possible deficiencies of knowledge and abilities of problem solving. Thus, in this method, rather than the teacher simply pass on the knowledge and then testing them through assessments it also takes students to apply their knowledge in new situations. Students face problems often poorly structured and try to discover useful solutions through investigation and research.

For the successful implementation of PBL as a pedagogical strategy, the following stages must be fulfilled (Savery, 2006): i) facilitator proposes a problem for the group of students; ii) students try to generate hypotheses and identify facts about the problem, through an initial brainstorming. Students also identify, based on the proposed problem, other issues that form the basis for conducting research and, consequently, acquire the necessary knowledge to solve the problem; iii) students formulate and analyze the problem, aiming to generate ideas for its solution; iv) students, assisted by the facilitator, identify knowledge gaps for solution of the problem; v) students seek for new knowledge related to the domain and try to generate new facts about this knowledge; vi) In the end of each problem, the student reflect about the knowledge acquired.

PBL, when applied correctly, provides some benefits, among which stands out (Hmelo-Silver, 2004): develops critical and creative thinking; increases the ability to solve problems; increases motivation; help students to apply their knowledge in new situations. Several studies in the literature (Yadav et al., 2011), (Savery, 2006) indicate that learning is enhanced through social interaction and is facilitated when students are exposed to real life situations. The metacognitive ability "What should I do?" or "How should I do?" and "Did it work?" promote effective learning processes, self-regulated and continuous. These two aspects may also increase the epistemic motivation, in other words, motivate students to want to know more about the problem addressed.

PBL in Teaching Computing and Engineering

Due to a very large number of factors, such as expanding the field to professionals in Computing and Engineering and the increased competitiveness of the job market (Morgan et al, 1998), these students face many challenges such as changing job or position within the company, working in different sectors or even start their own businesses. This situation clearly requires professional with great adaptability and ability to learn new knowledge, often in an autonomous way (Ribeiro & Mizukami, 2005).

Thus, becomes obvious that there is an important challenge in teaching these students, particularly in recent decades. It is no longer possible to train professionals without worrying about their placement in the job market, as occurred when there was a great shortage of specialized work force. Currently, these courses need - in addition to providing a solid technical / scientific training to these students - attend to the development of other professional attributes that contribute to a better performance and greater employability and give them more flexibility in their future careers (Ribeiro & Mizukami, 2005).

Thereby, efforts should be undertaken to provide these students:

- **Knowledge:** Knowledge of foundations (science and technology) and the relations between the various areas.
- **Skills:** Development of projects in laboratory or in field, analyzing problems, synthesis of solutions regarding current practices, communication, teamwork, management of resources and processes, self-assessment and peer assessment.
- **Attitudes:** Ethics, integrity and accountability to colleagues, society and the profession, concern for the environment, initiative, entrepreneurship, adaptability, motivation and interest in autonomous and continuous learning throughout their lives.

However, it still seems to predominate conventional teaching methods mainly in teaching Computer and Engineering (Ribeiro & Mizukami, 2005), i.e., guided by the transmission / reception of knowledge through expositive classes, which can take various forms, such as teacher lectures, students workshops, use of media (e.g. computer programs and educational films). In this environment, students usually participate passively and individually and their work and performance are evaluated by tests which generally measure their ability to memorize facts, formulas and procedures.

Despite the probable difficulties, several authors (Borrego et al., 1993) and Bordogna (1993) reaffirm the need to reform education and the adoption of alternative methods in order to better provide the needs of training of these future professionals responding to the objectives perfectly presented here. Among these methods, PBL has been widely used, as it is known, according to Savin-Baden (2000), for offering students a way to learn knowledge and develop the skills and attitudes valued in professional life in the curricular context, i.e. without the need for courses or specially designed courses for this purpose.

On the other hand, it is important point out that many university teachers come directly from baccalaureates and graduate programs with little or no pedagogic content, and their experiences are based more on their research accomplishments than on their teaching performance. This fact may be closely related to lack of interest and motivation of students to learn.

Ribeiro & Mizukami (2004) describe the implementation of PBL at the University of Newcastle (Australia), analyzes its distinction regarding the original model and reflects on the feasibility of using this model in curriculus engineering in Brazil. The authors describe the wealth of the projects presented by the students at the end of the PBL cycle despite the difficulties encountered by the unpreparedness of some teachers. It could be identified in the work of Ribeiro & Mukukami (2004) successful implementation of PBL seems to depend on training of actors involved in this model. It includes the preparation of administrators, teachers and students who generally come from a process of schooling based on passive reception of knowledge. Therefore, teaching with the use of PBL should also be directed to the initial and continued teacher training faculty.

Kolmos (2012) discusses the fundamental principles of PBL in engineering education that can be applied in practice: the use of problems as a starting-point for the acquisition and integration of new knowledge, new information should be acquired through self-directed learning, it should be student-centered, learning should take place in small groups, and teachers should act as facilitators and guides rather than informants. Furthermore, author discourse about a PBL curriculum model, which can be used for analysis and development of the curriculum or single courses.

Courses in computer science, there is the requirement of theoretical training, mathematics and technology education, skills that enable to follow changes in technological innovation, which requires education also focused on content, but it also requires practice through of questioning. Many subjects of Computer Course, by their

nature, focus on problem solving for attachment content through lists of exercises that are often resolved individually, with the correction centered on the teacher.

The use of PBL in undergraduate computer science, is becoming the subject of specific studies, as in (Yueh and Lin, 2005), which provides a case study of the application of PBL through a Web-based environment's. Experience described in (Greening et al., 1997) discusses PBL in teaching "computer programming". Hamalainen (2004) report the application of PBL in teaching Computability Theory. The work of Linge & Parsons (2006) addresses an initiative in teaching Design of Computer Networks. Shen & Juang (2006), the authors investigate the applicability of the PBL approach to teach Artificial Intelligence course. All the experiences of the above studies show that, in general, student performance has improved, and that students have strengthened their capacities to better use in the courses.

PBL in HCI

Specifically in Computer area, the HCI course is usually offered in the higher education courses of Computer Science, Information Systems and Electrical Engineering (with emphasis in Computer Science). This course has issues ranging from human factors, user-system interaction design, user interface design until the evaluation of interactive systems. HCI research can aid in the design, development and implementation of Information and Communication Technologies (ICTs) and can improve students' abilities to design interfaces to these technologies. The content related for the PBL application was the evaluation of interactive systems.

HCI research can aid in the design, development and implementation of information and communication technologies (ICTs) and can improve students' abilities to design interfaces to these technologies. This work can be improved by exposing them to the techniques and findings of HCI. Four main themes should be a part of HCI classes in New Media programs. Students should:

- Understand that HCI is a rigorous, methodologically sound, and theoretically grounded procedure for evaluating and improving the design, and use of ICTs.
- Understand that HCI research has practical applications in the systems development lifecycle that have significant impacts on the organization's bottom line.
- Be familiar with the best practices as revealed by the current research findings.
- Be able to apply their knowledge of HCI to a wide variety of situations in their work.

Vasiliou et al. (2013) presents a case study in which we employed PBL methodology to teach HCI in a postgraduate course. The activities were situated in a multimodal information space, rich in digital and physical elements including personal computers, projectors with downwards projection, tablets, iPods, digital pen readers, stationery and a Facebook group for each team. This HCI course was organized in 3 hour weekly sessions, including mini lectures and group activities. The mini lectures were intended not to directly provide content, but form students stimulus to progress with their own research and acquire knowledge on their own. Group activities aimed to enable student engagement and active collaboration within each group were usually two hours long and consisted of three main units: (1) Weekly reflection: a 20 minutes session to summarize and reflect on what has been done since the last laboratory session. (2) Brainstorming: usually 80 minutes session to discuss about the progress of the project, readjust the problem based on the new facts and discuss ideas. (3) Self Study Assignment: a 20 minutes session to define what are the groups learning objectives and form a to-do list. The authors administrated questionnaires assessing students' motivational beliefs and overall satisfaction with the learning experience. The results show that students' overall

satisfaction was highly rated, while the information space contributed to students' engagement and collaboration.

Zaharias et al. (2012) describes an experience focused on teaching an introductory course in HCI by employing a 3D virtual world. According the authors, recent research studies argue that virtual worlds are fertile environments for implementing PBL processes. Groups of three students prepared a literature review on a specific area of IHC and performed a 20 min presentation, followed by questions from the class and the instructors. In addition, there were a total of two assignments for this course. The first was an individual assignment and the second assignment was a group-based project of four students. Assignment 1 aimed to introduce the students to basic usability issues. Specifically, they were asked to choose any interactive device, describe its tasks and evaluate its usability. Assignment 2 aimed to teach the students all the phases of the User-Centered Design (UCD) process with an emphasis on interface design, utilizing a Virtual World. A series of introductory tutorials on virtual worlds, OpenSim and Second Life were conducted (i.e., how to configure an avatar, how to create objects, etc.). After the end of this study the authors conducted structured interviews with the students participated in this study and key positive outcomes were: improvement of communication skills; collaborative learning effective; possibility of continuing the work at any time and from any place; possibility to monitor and comment the work of other groups; increased student motivation. The problems of this PBL study were related mostly with technical and not educational issues. For example some interactive objects were not working as intended in some cases while the use of voice chat was quite problematic. As a result this caused students' frustration and irritation.

Rosenbaum & Swan (2003) presented a combination of PBL and scenario-based instruction as an effective pedagogical strategy for teaching New Media students about HCI. This was followed by a brief scenario and suggestions for how it could be used in a problem-based design class as the basis for a semester long team project.

There are other works in the literature reporting the use of PBL in HCI (Vat, 2001), (Vat, 2006), (Nordahl & Serafin, 2008), (Tan, 2011). These studies prove its effectiveness to improve the process of teaching and learning. The motivation for the use of PBL in this research was due to the perception of the subject teacher: the students were taking a very passive role in the classroom, which caused a lack of motivation in their learning, especially when it comes to usability evaluation, and developed a perception that students would not be able to hold a job in the market based on the theory presented, because the content was superficially absorbed.

CASE STUDY

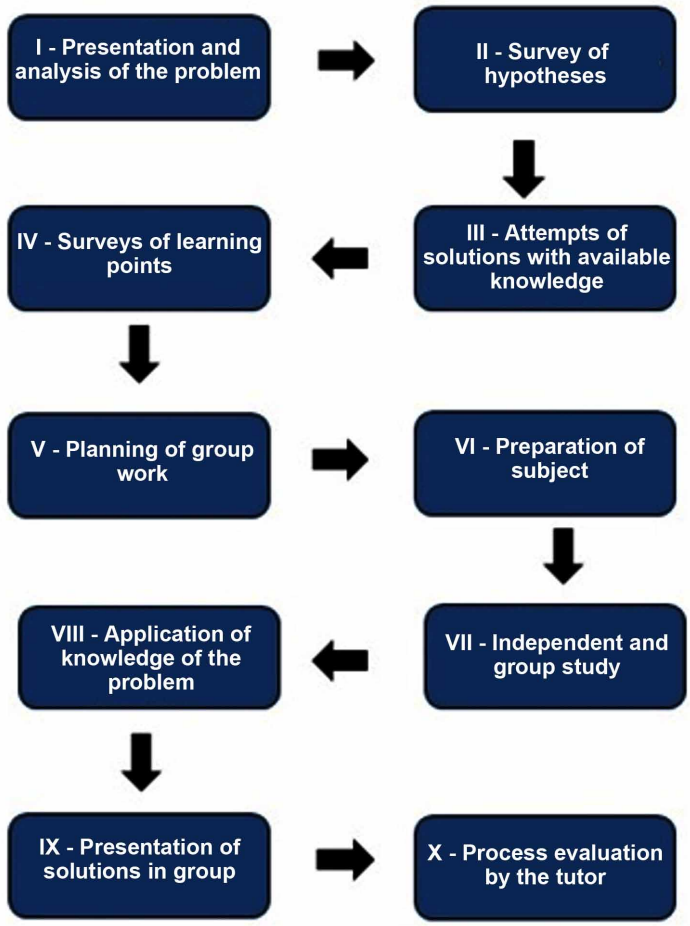
In order to validate the use of the methodology proposed here, a case study was selected. The description of the system used and the application of the methodology and the results collected are discussed in this section.

Methodology

The PBL methodology used in the project, adapted from Ribeiro (2011), consists on a sequence of working cycles based on problems (Figure 1). A cycle begins with the presentation of a specific problem, which is presented by the teacher and discussed by the students in groups (Step I). After the presentation and analysis of the problem, students, facilitated by the teacher, discuss and develop hypotheses about the causes of the problem (Step II).

In stage III, students evaluate the hypotheses by comparing them with the information found in the problem and try to solve it with their prior knowledge. This step is an opportunity for students

Figure 1. PBL cycle adapted from Ribeiro (2011) for teaching HCI



to present their disabled and misconceptions concepts about the subject matter, which can be immediately rectified by the teacher.

When students do not succeed in solving the problem with the knowledge they have, they raise points or learning issues (concepts, theories, etc.) needed to solve it (Step IV). Then, in Step V, plan the work of the group (Which points will be prioritized? Who will search them? What sources are used? When, how and where new information will be shared?). According to the collective work plan, students are required to prepare the project execution (Step VI) materials. This step was included in the model proposed by Ribeiro (2011), because in the teaching of usability evaluation is necessary the development of instruments for data collection and in the case of involving end-users, is also essential to prepare cover letters, scripts of software test sections, among others. All these materials are prepared based on scientific studies in the HCI area.

Step VII has also undergone transformation. Ribeiro (2011) proposes the independent study with meetings not tutored. However, there was also the need to include the study in group. In addition, it is recommended that the student control the time that a user spends on each activity proposed in the evaluation script. In step VIII, students apply the

knowledge gained in solving the problem many times as necessary until they reach a solution that the group deems satisfactory.

The final stage of the problem-solving cycle involves the production of a report that is presented to the teacher and to other groups during presentations (Step IX). Ending the cycle, students also evaluate the process, their products, the work in group, their own performance as much as the performance of other members of the group (Stage X).

Description of the System Used

APICE Web platform is a system created to support the learning of science through the development of research projects; it is intended for managers, teachers and students of primary, secondary, technical and higher education. The contents and materials, which are free, have been developed by four content-professionals, experts in the orientation of research projects, based on books and specialized materials available in the literature. The first course created and made available on the APICE platform was Scientific Methodology. Another course on Organization of Science Fairs is nearing completion.

To ensure the quality of production process of the courses, we sought to standardize the way of creation of such content. For that a document containing some instructions to guide the content-production of the modules that make up each course was made available. A course, of this platform consists of several modules, proof of certification and a progress bar. A module is organized into units and has the following structure: welcome to the module, opening video, units, review, QUIZ, suggested reading, references.

Development Process

The development process used was a prototype, which uses top-down and bottom-up approaches in order to generate faster versions (Sommerville, 2001), (Pressman, 2006) that are tested and validated by professionals in education, involved in all developmental stages.

The choice of "Scientific Method" course is linked to the need, of the authors of this work, in offering courses to support teachers in elementary and high school in the orientation of research projects for Science Fairs. The authors of this work have promoted, for 10 years, a science fair that, among its objectives, in addition to stimulating the planning and execution of projects by students and teachers, seeks to value the qualitative aspects of scientific production. During this time, several strategies were adopted by the organizers of the fair in order to contribute to improving the quality of the finalists such as lectures and workshops offered to mentor teachers and counselors during the exhibition of projects by students on Thursday and short courses offered in person in some Brazilian states.

Despite the positive results obtained through the strategies noted above, the range number of teachers is restricted to participants attending the fair or who seeks the mini-courses. Through the APEX platform, we search to increase the number of teachers interested in this qualification, since it is based on a free system and high availability (available online on the web). In addition, Web systems enable use of hypermedia objects (interactive audiovisual resources) to expose complex concepts, besides allowing obtaining feedback from solved exercises, calculating rates of hits and misses, among others.

Regarding the interface requirements, APICE should allow users to have free access to courses in an intuitive and dynamic way. There is a need on the part of developers to obtain statistical data related to the profile of users (administrator, teacher or student) who attend the APICE courses. Therefore, it was requested an interface registration and authentication on the platform. The register aims to identify and permission to access a particular course. The authentication

allows user data to be linked to a user name and password. It was also requested a progress bar so the users can view their status in the course. The bar should show both the percentage of completed modules in a course as the content studied in a particular module.

In relation to the requirements of content and interaction, courses should provide users with general and specific knowledge about the treated subjects, whereas the interaction should allow sedimentation of this knowledge. The content of the courses (modules) should be available in index form, accessible through the progress bar, so the user can navigate the course as you wish. Videos, animations and sounds should be part of the content, because at the same time help motivate the learner and smoothes the transmission of content.

Design and Implementation

The APICE platform was implemented in a HTML programming language (HyperText Markup Language) and CSS3 (Cascade Styling Sheet), Javascript and Python programming language. It was created a system to supply the content and dynamic generation of pages. About the art, the compositions were performed with Adobe Illustrator tool, based on vectorized images available on the Internet. Figures 2, 3 and 4 show two examples of screens in Course of Scientific Methodology.

Application of the PBL Method to the Teaching of HCI

Considering the steps of PBL model suggested in this study, the 10 stages included in Figure 1 were distributed as followed:

Step 1: The problem / project chosen for the course was fundamental for the student motivation. It was a real system, which would be deployed with the improvements suggested by groups of students, through their usability evaluations. The system consists of several

Figure 2. Logbook Module

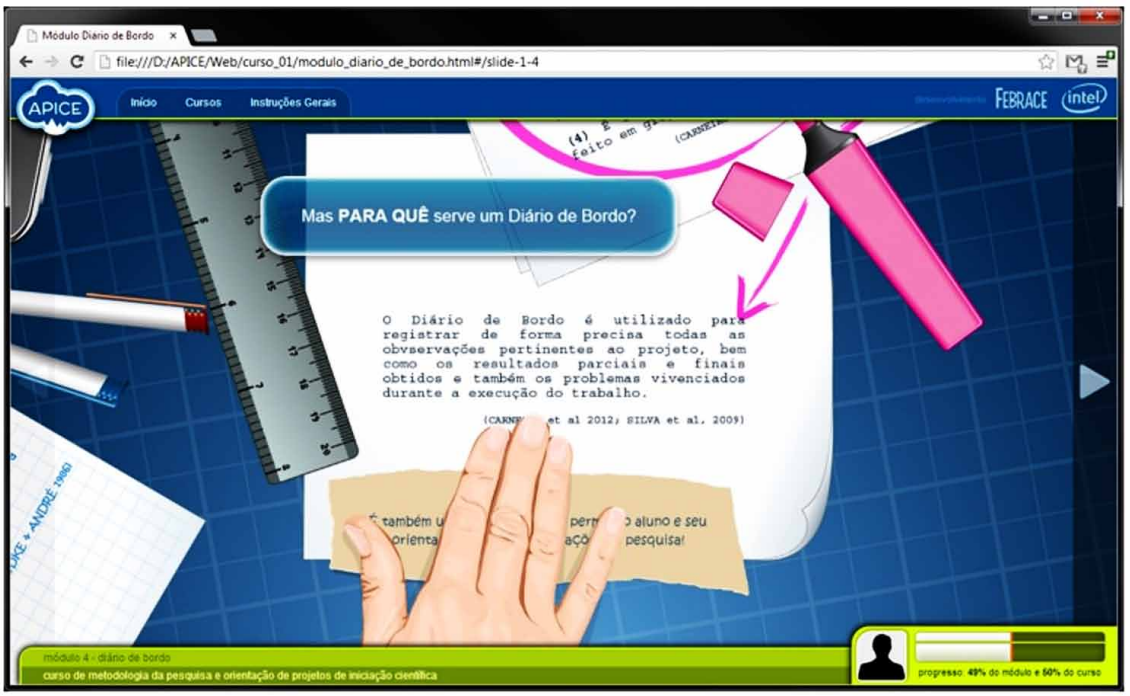


Figure 3. Research Completion Module

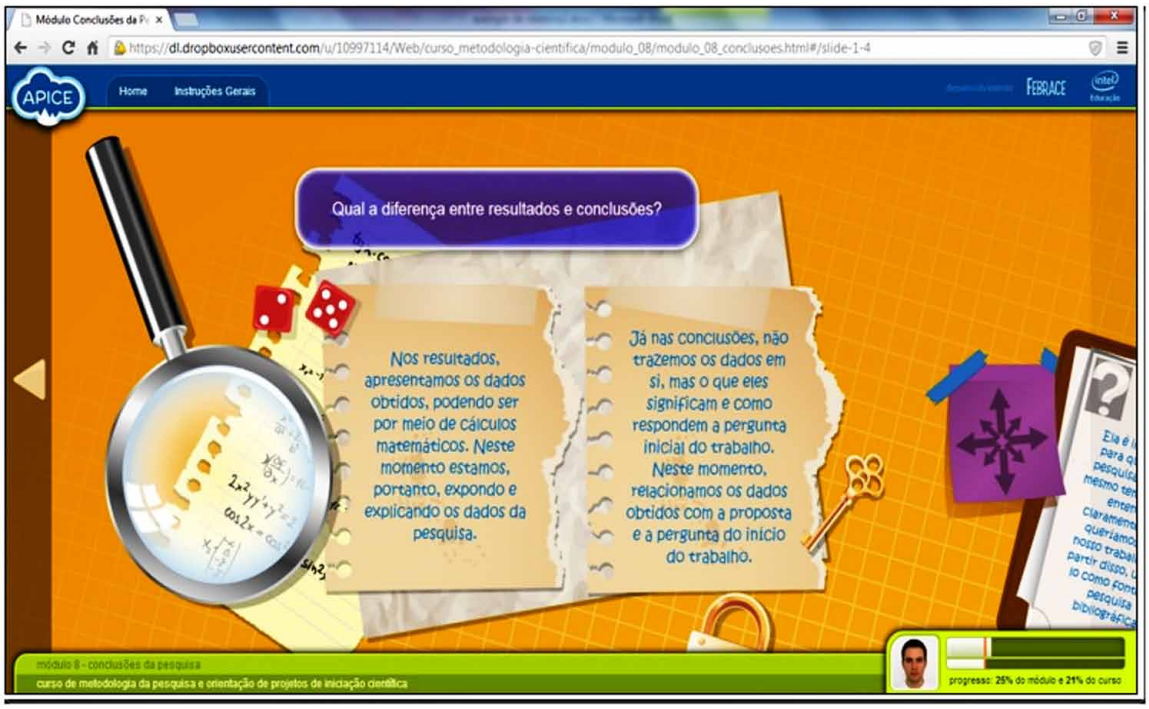
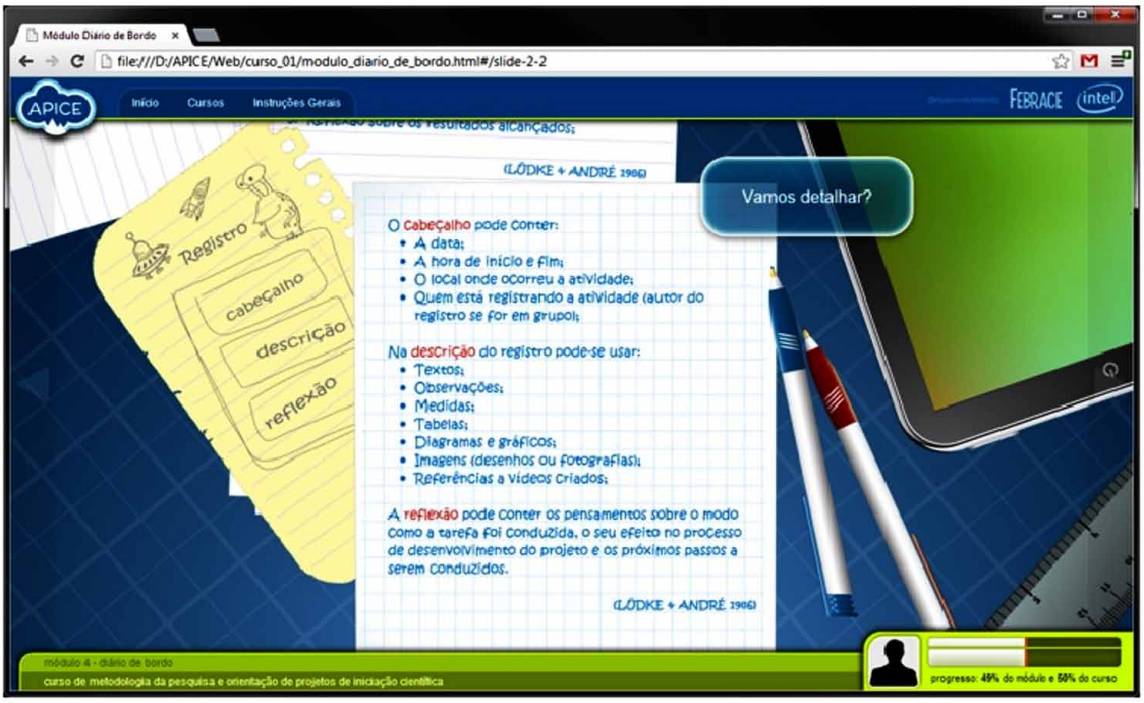


Figure 4. Revision module course screen



online courses aimed at managers, teachers and students of primary, secondary, technical and higher education.

Step 2: After the problem definition, students, tutored by their teacher generate hypotheses that could solve the problem in question: "what goals of usability and user experience are being violated?". At this point, the teacher had the opportunity to rescue the subjects handled at the beginning of the course where the goals of usability were discussed (effectiveness, efficiency, safety, usefulness, ease of learning and ease of memorizing) and the user experience (fun, satisfying emotionally appropriate, rewarding, interesting, pleasant, helpful, motivating, aesthetically appreciable and encouraging creativity).

Step 3: With clearly defined hypothesis, students, based on their prior knowledge, tried to provide answers that could solve the problem in question. In the matter of an online course evaluation, according to the students, a possibility to examine whether the goals of usability and user experience are being met, it is necessary to: navigate the system for problems at the interface; observe real users using the system; interview users who used the system. The question is: how to do it? Is there any procedure? Any methodology?

Step 4: In this stage the teacher has the opportunity to present the techniques for the interactive systems evaluation. Several techniques can be presented and the teacher, along with the students can list the most suitable for use. The methods chosen by the teacher to teach Usability Evaluation for students of both courses were classified into two dimensions, according to:

a. **Usability Inspection:** does not involve users and can be applied at any stage of system development, whether this is implemented or not.

b. **Usability Testing:** necessarily involves the user and includes experimental and empirical methods, observational methods and questioning techniques. In this case, it is necessary that the system holds some real implementation..

At this point, there was a strengthening of the content already presented in class, in which they reviewed, through practical exercises in conjunction with the teacher, on inspection and evaluation of usability. Thus, before the proposed project, the students gathered in spontaneous groups, needed to perform two activities on the system evaluation: Usability Testing with users and Usability Inspection. This involved among other actions that the students would play: critical thinking, ability to work in a group, ability to communicate with the user, synthesis and analysis of the resulting data, and, of course, to hold in-depth knowledge level of the usability evaluation.

Step 5: Based on the problem to be solved and the new knowledge acquired, students plan the work in group. In the case of usability evaluation is necessary that students discuss and decide the following questions: Who are the members of the group? What are the responsibilities of each member of the group? Who is the target audience of the system? Where and when assessments will be conducted? How to collect data? How will data be analyzed? What is the format of data resulting (report)?.

Step 6: The preparation of materials to be used in the evaluation is given on this step. Usability testing for the data collection instruments was developed by the authors of the work in conjunction with the student-learners who would then verify the viability, adaptation (if required) and organization of material. The questionnaires were developed: a) pre-test, based on and adapted from Larsen, Fink & Granum (2003) questionnaire, to raise the profile of the user; b) post-test questionnaire based on the criteria of usability evalua-

tion proposed by Nielsen (1994), to collect opinions about the actions, tasks and system features. The post-test questionnaire was composed of 25 questions, with the first 20 multiple choice, varying according to the Likert scale (Likert, 1932): "Strongly Agree", "Agree", "Undecided", "Disagree" and "Strongly Disagree, and essay 5 remaining. As for the Inspection Usability, for the case of groups formed by students learning to use the inspection technique, and not truly experts, was conducted by professors (experts), a union of heuristics (Nielsen, 1994) and of inspection model called Usability Inspection Technique Based on Web Project Perspectives (Larsen, Fink and Granum, 2003), which uses checklists to guide the evaluators.

Step 7: Students test and validate the data collection instruments developed in the previous step. Usually, after the development of these instruments, the students are asked to test them in a pilot test aimed at finding problems, both in relation to the questions, and in relation to the response options. At this time, studies on scales of measures are needed

Step 8: The student-learners have done two evaluations. with prepared and approved materials, In Usability Testing, the subjects involved in user testing totaling 82 (eighty two) students of Computer Science and Information Systems in a Higher Education Institution which were enrolled in the survey period, the course of Scientific Methodology . Student-learners of HCI course were people who applied the tests to end users, accompanied by the subject teacher. First, the teacher explained and simulated how students should act and then the students could apply the tests, based on a how to proceed script. We have selected four modules for evaluation out of the 14 modules that make up the Scientific Methodology course. Each module is assessed by a group of users separately. The criteria for selection and allocation of modules for each group were random. Both the questionnaire pre-test and the post-test were applied to individual students. It is worth mentioning that this audience (students), for being in IT, has a fairly high degree of dissatisfaction, diverging probably the public profile that effectively use the system. This, actually, is quite positive, as the correction of the system happens according to the most critical opinions about it. You can also say that, several times, users resemble usability experts. For the application of the tests, these users had an introduction to the topic and description of the activities to be performed for about 5 minutes and 3 minutes to answer the pre-test (profile-related issues). Afterwards, they could experience the application for 20 minutes each. The post-test, with the questionnaire, lasted 15 minutes on average. In Usability inspection, each of the students in each group, here called evaluator and under the supervision of an expert, surfed the system individually and pointed usability mistakes (what kind of problem was found, where the problem occurred and its severity), according to a checklist created by the authors containing heuristics evaluation. Subsequently, the data from each evaluator were compiled into a single group list.

Step 9: Each group concocted a report containing a list of problems found during the online course obtained from: a) Usability testing with users: in this report, there was the user opinion regarding the criteria related to: effectiveness, efficiency, ease of use, subjective satisfaction, ease of learning and ease of memorization; b) Usability Inspection: held, first individually and then compiled into a single list of members of the group. At this point, the teacher assessed how much the group achieved in solving the problem (finding usability problems).

Step 10: Through informal interviews, the teacher managed to capture the impression of the learning of each student and the group. The fact that it involves a concrete problem motivated very much the students and they have exposed that, through this real project, they were able to learn the theory(and not only through examples, even though these are practical knowledge) and that they felt able to apply this project in the labor market. The questioning exposed to students, on the last day of class, to evaluate the PBL method in the teaching of IHC were the following: (a) Did you think the project contribute to the learning of the theory of IHC? (b) Did the project enable to develop problem solving skills? (c) Did the project provide an opportunity to work in a group? (d) Did the project instigate the performance of roles within the group? (e) What is your opinion about the teaching of HCI in solving a real problem?

Results and Discussion

Among the main results, observed by the teachers, the reports and also in monitoring students' activities with end users and inspection, the adoption of PBL in teaching HCI provided to students:

- Develop ability to identify relevant aspects of the problem under study, ensuring timely discussions within the project context.
- Acquisition of certain autonomy to perform entirely a project of usability evaluation, both for tests with end users, as inspection of usability.
- Develop an adequate knowledge base to define and manage the problems arising from the activity of usability evaluation of web systems.
- Intensification of development of an effective reasoning process, including the analysis and the synthesis.
- Make a critical assessment of information about the problem.
- Ability to communicate with the target audience.
- Ability to evaluate critical systems, in relation to usability, which interferes even in the way of these students in systems development.
- Regarding the development of the Project, the implementation of PBL led students of Computer Science and Information Systems:
- Select techniques for usability evaluation of web systems.
- Identify and define the profile of the target audience.
- Develop questionnaires for data collection.
- Perform assessment of usability testing with 82 users.
- Perform inspection usability 4 modules of APICE system.
- Analyze the data collected.
- Prepare final report of Usability Testing.

One can also observe that, in principle, the presentation of the problem (project), students felt uncomfortable of not being part of a passive role learning anymore, where the teacher was the holder of knowledge. This problem was overcome in the course of the project, and the students have adopted the posture of active agents of their own learning. In informal conversations with students, teachers recognized the great motivation of these students, especially knowing that the design of usability evaluation would, in fact, used by system developers to improve it.

CONCLUSION

This research aimed to contribute to studies on the use of PBL teaching model in IHC. The approach used in the course of HCI College of Computing

and Informatics, Mackenzie Presbyterian University, was well received by students. The questions, made in the form of debate on the last day of class, showed that, in the opinion of students:

1. The project encouraged students to research and search for theoretical knowledge of IHC, since they become protagonists of a real case study, where they had to deal directly with the customer.
2. The application of methods for evaluating APICE usability helped explore specific problems of evaluation of interfaces: how to decide the method of valuation to be applied; planning the evaluation; how to collect the data; how to make and present the analysis of results. In the authors' opinion, it is important to emphasize that the teacher had a key role to push up the adoption and implementation of solutions and research done by the students. However, one of the greatest contributions of PBL is that students look for possible ways to solve the problem, discuss as a team the pros and cons of adopting each solution found, and therefore they are more able to absolve the concepts and methods discussed in the course.
3. Group work led to the development of creativity and hence the emergence of new ideas, and enable cooperation among team members. The authors emphasize the value that should be given to group work in the classroom, once in all fields of life, the human being does not work alone. The division of work in teams is increasing, making the day to day more dependent on a group of companies and individuals that compose. So create strategies that promote the ability of cooperation, discussion, active listening, respect differences and helping others can help with learning experiences more cooperative, rather than competitive. When the group controls the learning process, their learning is faster, more relevant, and sustained.
4. The way the groups were formed and structured secured balanced division of workload and distribution of tasks. Although the roles of team members have been agreed at the beginning of the project, there was a need for students to act in a central problem. From this, it is necessary to redesign the specific targets, causing the performance of students in other roles or bringing new responsibilities.

Students believe that the use of different methodologies, such as solving real problems, help the learning. There was an indication that the investigative teaching contributed to the motivation and interest of students. Allows us, therefore, conclude that the investigative teaching, from proposals brought by PBL promoted learning of these students in a pleasant way, showing that effective teaching can be done through this methodology.

5. Reinforce that PBL is shown here in this paper as an option of viable education method. However, it is important point out that many university teachers come directly from baccalaureates and graduate programs with little or no pedagogic content, and their experiences are based more on their research accomplishments than on their teaching performance. This fact may be closely related to lack of interest and motivation of students to learn.
6. Obviously, there are many obstacles in the use of PBL, such is: reduced control over content coverage, increased vulnerability and teaching-related workload, the data of the case study suggest that the PBL format adopted can be important may be especially important for students by making lessons more dynamic and making them learn more.
7. Although it is difficult to generalize from a case study, the activities found in this and other PBL formats can encourage teachers

to reflect on their teaching practice and the need for continual improvement. In this sense, it is possible to improve the lack of pedagogical contents, PBL can be a catalyst for professional development of these teachers in universities.

8. The case study suggests that PBL can be used in curricula of Engineering, Architecture and Computer, albeit in non-curricular deployments. It seems that even partial deployments in the gains justify its adoption. However, it must be reiterated that this methodology does not solve all the dilemmas of higher education. It's just one of the alternatives to teaching based on the transmission and reception of knowledge model.

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KEY TERMS AND DEFINITIONS

Human-Computer Interaction (HCI): Is the study of how people interact with computers and to what extent computers are or are not developed for successful interaction with human beings.

Inspection Usability: Is aimed at finding usability problems in the design, though some methods also address issues like the severity of the usability problems and the overall usability of an entire system.

Problem-Based Learning (PBL): Is an instructional, learner centred approach that empowers learners to conduct research, integrate theory

and practice, and apply knowledge and skills to develop a viable solution to a defined problem.

Usability: Is a quality attribute that assesses how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the design process.

Usability Testing: Is a technique used in user-centered interaction design to evaluate a product by testing it on users.

User-Centered Design (UCD): Is a process in which the needs, wants, and limitations of end users of a product, service or process are given extensive attention at each stage of the design process.

Section 2

Engineering Cases

Chapter 9
Motivation on Problem Based Learning

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ABSTRACT

In order to motivate the students in a Problem Based Learning environment, two different strategies are analyzed. The first one consists in introducing two crosscutting issues such as the ecology and the study of patents. In that strategy, the students need to solve the activities taking in account this "green component" to obtain the best solution as well as the study of patents (which is the process to patent something), that engineers need to know to develop their professional career. The second strategy is to analyze the motivation of students when PBL is combined with different instructional methods, different objectives and in different courses. In order to do this analysis, we have implemented different practices that includes both e-learning and m-learning. Finally, we analyze the motivation during our PBL courses through a survey. This analysis has been done in three different subjects in a Telematics engineering degree at University of Extremadura, Spain.

INTRODUCTION

The new context of the European Area for Higher Education (García-García et al., 2009) and the current social environment marked by new technologies imply that new Telecommunication Engineers must be trained not only in technical knowledge but also in the professional skills that they must use in their professional life (Cajander & Daniels, 2011). The effectiveness of hands-on experience to produce meaningful learning has been clearly demonstrated, for example (Gil et al., 2010), (Martínez et al., 2012), indicating the need to train university students in specific professional skills. Over the last few years the ABET engineering criteria (ABET, 2013) have served as a guideline to develop professional skills in order to achieve this. In Problem-based learning (De los Ríos et al., 2010) (Kartal & Bakaç, 2010), students are confronted with an open-ended, ill-structured, authentic (real-world) problem, whereas Project-based learning begins with an

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assignment that must lead to the production of a final product—a design, a model, a device or a computer simulation. The former method is always active and collaborative and, typically, involves significant amounts of self-directed learning on the part of the students.

This methodology, PBL, as a teaching strategy and curricular design began at the McMaster University School of Medicine in Canada in 1969. Using problems based on actual clinical cases as focal points in a medical program evolved after years of medical faculty and student frustration with the traditional lectures and challenging clinical experiences. Imparting and absorbing the immense amount of content inherent in a medical education was becoming more unrealistic and improbable. Drawing from the tutorial process developed by Barrows (Barrows, 1985), (Barrows, 1988), (Barrows, 1971), (Barrows, 1980), (Barrows, 1996) the medical curriculum shifted from a faculty-centered approach to a student-centered, interdisciplinary process. Starting from this initial learning strategy, many schools in different parts of the world have adopted this methodology usually with some variations to suit their local needs. However, the spread of the methodology was not homogenous all over the world. Whereas in North America the impact of PBL was very strong, due to the long academic traditions of American colleges and universities with their focus on personal development of students, the inclusion of PBL in Europe was very different.

The first European PBL curriculum was introduced in 1974 in the University of Maastricht (The Netherlands) Medical School. This medical school was founded in that year, with the explicit mission to explore innovative forms of teaching and they implemented the PBL as the main learning strategy in their courses. Today, PBL is widely spread in different fields of higher education. A complete review of the works done with PBL in the first 25 years of the methodology can be found in (Albanese & Mitchell, 1993), (Norman & Schmidt, 1992), (Mohd-Yusof et al., 2011).

Despite the long time from the initial development of the methodology, more than forty years, the inclusion of PBL at universities is growing yet. Nowadays, the PBL is complemented with the new learning methods, such as cooperative learning, on-line learning or e-learning and mobile-based learning or m-learning. For example, the cooperative learning refers to a set of instructional strategies in which students work together in small groups to help each other learn academic content. This kind of learning improve the teamwork skill and develop some social skills, some capabilities key in the 21st century engineer profile. The benefits of this combination are defined in (Salaberry et al., 2005), where the authors indicate that "Combining PBL with cooperative learning provides a mechanism for students to maximize their own and other group members' learning by working in teams to accomplish a common task or goal". Other implementations of cooperative PBL can be found in (Maskell & Grabau, 1998), (Miao & Haake, 2001). Another example of the integration of PBL with other learning methodologies is the appearance of PBL in virtual learning environments (Quesada, et al., 2013) (Ching-Pu et al., 2011) (Yajie et al., 2010) (Ali & Samaka, 2013) (Secundo et al., 2007) (García-Robles et al., 2009) (Schmidt, 1983).

As we have stated previously, the methodology problem based learning increasing its popularity day by day. Nowadays a lot of Universities implement this methodology. We have implemented this methodology in several courses (Lozano-Guerrero & Valenzuela-Valdés, 2014), (Valenzuela-Valdés et al., 2014), (Carmona-Murillo et al., 2014). This methodology is easy combinable with other methodologies as e-learning or m-learning. Thus, PBL is very flexible methodologies that permit us implement several innovations, moreover this methodology has been used by other authors to implements several innovations as:

- PBL used in order to provide different skill. It is necessary to train university stu-

dents in specific professional skills. In order to achieve this, over the last few years the ABET engineering criteria (National Research Council, 1995), (ABET, 2013) and the influential work done in (Shuman et al., 2005) have served as guides professional skills. In our courses we have developed several PBL in order to develop different skills.

- PBL merged with Hands-on through specific instrumentation and simulation hardware devices to produce meaningful learning as referred in (Drosopoulos & Hatziprokopiou, 2010), (Hofstein & Lunetta, 2004), (Jung, 2013), (Gonzalez et al., 2013).
- PBL merged with M-learning (Munoz-Organero et al., 2012), (Liaw et al., 2010), (Evans, 2008) is a methodology that uses mobile devices, such as phones, tablets, iPods etc. Additionally, time optimization has become a key skill for our students. Studying at any time or place has become a common practice and portable technologies make it possible.

On the other hand, Barkley defines student engagement as "a process and a product that is experienced on a continuum and results from the synergistic interaction between motivation and active learning." (Barkley, 2009). Now, our objective is to analyze the motivation on the courses that implements PBL methodologies Thus, it is necessary provide active learning to students and keep on the motivation high during all the learning process in order to increase their learning gain.

Moreover, in this days, some of the main challenges posed to engineering education are the demand of new technological innovations and at a fast rate together with the address of sustainable concerns and the contribution to a more fair and sustainable future (Bourn & Neal, 2008). To address sustainability problems, engineers need new kinds of knowledge, competencies and skills, calling for a new type of engineering education able to support the development of the mentioned knowledge, skills and competencies. Furthermore, integration of sustainable development has been emphasized by engineering education research, accreditation boards and organizations. With this challenges in mind, in this chapter we describe two strategies followed in a Telematics Engineering degree in order to improve the motivation of the students through a technological topic such as the study of Patents and a sustainable topic such as the ecology issue in networking.

Thus, the organization of the chapter is as follows. First, we review the main strategies that improves the motivation during the learning process. Then, the approaches followed in our experience are introduced. Section 4 analyses the motivation in three different subjects in a Telematics Engineering degree. Finally, some conclusions are given.

LITERATURE REVIEW

It is generally agreed that motivation is beneficial for learning and achievement. Some authors have concluded that motivated students invest more time in their courses and more likely to complete their study programs (Pintrich, 2003); whereas unmotivated students are more prone to drop out (Wijnia et al., 2011).

Moreover, it is known that in PBL activities, the quality of the problem can influence the motivation of the students (Noordzij, 2010), the interest level of problems in PBL was positively associated with intrinsic motivation.

In this sense and regarding to the motivation process, we can distinguish between the different factors that contribute to student motivation and the specific mechanisms (tools) that the teacher uses in order to achieve a higher level of motivation in their students. With respect to the factors

that make the students to be more motivated, this issue has been widely studied. However, the possibility to apply those factors in specific activities for engineer students have not been so studied.

Most of the studies, however, have not examined subject area or disciplinary differences in these classroom features. Although the contextual differences among classrooms of different academic disciplines may not seem pronounced, there is evidence that significant differences exist among teachers and classrooms representing different subject areas (Wolters & Pintrich, 1998).

In this section we review the main interesting mechanisms for activation and persistence of the students' motivation in an engineering environment. Special attention is given to the technological areas such as Computer Science and Telecommunications.

In recent years, many innovation teaching projects are arising due to the necessity to improve the traditional methods that do not offer a motivation to the students. In an effort for grouping the main strategies, we can consider the following generic groups: Game-based learning, competition-based learning and simulation-based learning.

In some cases, this way of grouping is not strict and in many cases a motivation strategy can rely in more than one group. For example, in (Burguillo, 2010), the authors introduce a framework for using game-based tournament as a base to implement Competition-based Learning, together with other classical learning techniques, to motivate the students and increase their learning performance. They conclude that "the good survey results, and their similarity along the years, suggest that the combination of game theory with the use of friendly competitions provides a strong motivation for students; helping to increase their performance". A more deep research in game-based learning strategies can be found in (Hwang & Wu, 2012).

With respect to game-based learning, (JISC, 2007) suggests that one of the main benefits of Game-based learning is the motivation. In fact, game-based learning offers a particular strength of motivating users and this is why many learning games have been developed for particular groups that have difficulties with sustaining motivation. The study made in (Papastergiou, 2009) assesses the learning effectiveness and motivational appeal of a computer game for learning computer science concepts. The results of this experience showed that, "the gaming approach was both more effective in promoting students' knowledge of computer memory concepts and more motivational than the non-gaming approach". They study also investigated potential gender differences in the game's learning effectiveness and motivational appeal. In this sense, the paper reflects that "despite boys' greater involvement with, liking of and experience in computer gaming, and their greater initial computer memory knowledge, the learning gains that boys and girls achieved through the use of the game did not differ significantly, and the game was found to be equally motivational for boys and girls". So can be concluded that educational computer games can be exploited as effective and motivational learning environments, regardless of students' gender.

Other strategies are only based on competition-based learning. In (Munoz-Merino et al., 2014), authors presents an empirical study of students in a telecommunications engineering degree in which they measure their level of motivation, and their emotions about competition in education in general, and in particular about the Information System for Competition based on problem solving in Education (ISCARE). As a result the study "show that students had moderate levels of motivation and experienced no negative emotions while using ISCARE. Under certain circumstances, therefore, competition in education, using technology systems that provide competition, can produce motivation without generating negative emotions. Female students and students with low ISCARE scores were less motivated and experienced more negative emotions. In addition, motivation and emotions toward ISCARE were

more positive than they had been toward competition in general". Additionally the authors open an interesting discussion that can provoke this kind of competition-based motivation. In some cases, introducing competition between students can enhance their motivation, but it can also generate negative emotions. This view is also shared for other authors that suggest to avoid excessive competition. In (Callahan, 2012), it is said that "while students need opportunities to interact with their peers, and many students claim to be inspired by competition, you don't want to create an environment that is conducive to comparison, divisions, or derisive dialogue among students. These intense and extremely competitive types of classroom settings can induce performance anxiety which can interfere with student learning, thereby counteracting your goal of motivation".

Moreover, in some areas of engineering and especially in telecommunication the use of simulations is very common. In fact, from an educational perspective, the benefits of simulation-based learning are twofold. On one hand, students learn practical skills, which are essential for their professional career. On the other hand, they get a better insight about specific problems, which are usually very complex, because they deal with systems that have a behavior much closer to real systems that any other option. In fact, simulation-based labs becomes a substitution to real laboratory experimentation that needs the students to work on expensive, complex and, sometimes, in dangerous systems. Moreover, many higher education institutions are opt to simulation labs due to its cost, flexibility, and space in laboratory compared to real lab which needs more space, high cost, and less flexibility.

Some works such as (Koh et al., 2010) and (de la Rosa, 2012) deal with student motivation from this perspective. In (Koh et al., 2010) the authors investigate the effect of Simulation-based Learning (SBL) on learners' motivation and performance. Their findings suggest that the students perceived their psychological needs to be satisfied and had high levels of self-determined motivation. Students who undertook SBL had higher mean performance test scores, although SBL may have differential effects on learners depending on factors such as gender, educational backgrounds, and IT knowledge. In (de la Rosa, 2012), authors analyzes the use of behavioral simulation techniques to enhance the teaching-learning process in engineering courses for undergraduate and master students. The results of this experience reveal that students become highly motivated and satisfied with the proposed simulation-based learning methodology.

Apart from the three aforementioned strategies, Game-based, Competition-based and simulation-based, other interesting learning strategy very specific for computer science and engineering courses are robot-based learning. Many researches have pointed out that educational robots can stimulate learners' learning motivation. As the rapid development of robotics, it has become feasible to apply the educational robot for enhancing learning. In particular, computer-controlled models have been a useful aid in teaching computer science and networking concepts. Most of the papers in literature make use of LEGO Mindstorms® to deal with the activities for motivation purposes. Some papers (Panadero et al., 2010), (Behrens et al., 2010) show their experience using robot-based learning. In (Panadero et al., 2010) the authors describe a series of experiments using LEGO Mindstorms® that have been carried out since 2005 in several scenarios involving a variety of student groups and course levels. In this paper, it is exposed that "the purpose is not to discuss the appropriateness or disadvantages of using those LEGO kits to teach technical topics, but rather to show how they increase motivation and improve professional skills". The results reveal that the competition and social interaction experiences with robots are key issues that contribute to increase the student's motivation. The participation of the students in the experience "as a form of ac-

tive learning is highly motivating for students and contributes significantly to reinforce transversal skills (autonomous learning, problem solving and team work) learnt with this experience."

Another robot-based learning experience can be found in (Behrens et al., 2010). In this paper authors also emphasize in the capacity of practical courses to allow an early insight into the real world of engineering, augmenting student motivation and enabling students to acquire complex skills early. In this paper, a new freshman introduction course into practical engineering is presented. The experience is, "based on a threefold learning concept comprising mathematical methods, MATLAB programming, and practical engineering, where the students were required to transfer mathematical basics to algorithms in MATLAB in order to control LEGO Mindstorms robots. Toward this end, a new toolbox, called the RWTH-Mindstorms NXT Toolbox, was developed, which enables the robots to be controlled remotely via MATLAB from a host computer". The evaluation of this experience show that the project improves the students' MATLAB programming skills, enhances motivation, and enables a peer learning process.

As it has been shown, game-based, competition-based and simulation-based learning, together with robot-based learning are some of the most useful strategies tools to improve students' motivation in both computer science and telecommunications courses. However, these are not the only mechanisms that teachers have used to deal with motivation. In this chapter we combine different motivational strategies based on problem based learning methodology. As we have introduced in the previous section, problem based learning is a student-centered instructional strategy in which students collaboratively solve problems and reflect on their experiences. In PBL, learning is driven by providing open-ended problems where students usually work in small collaborative groups and they are encouraged to take the responsibility for organizing their group, and manage the learning process with specific support from a tutor or instructor that take the role of learning facilitator.

In next section we introduce the topics of the problems selected for the problem-based experience.

MOTIVATION THROUGH INTRODUCTION OF ONE ATTRACTIVE TOPIC

During the 80s and 90s there have been numerous empirical studies on the relationship between motivation, learning strategies and academic performance (Bouffard-Bouchard et al, 1991 Pokay and Blumenfeld, 1990; Pintrich et al, 1991). The different authors classify motivation into two different classes: extrinsic and intrinsic motivation as the different causes that lead to action (Porac & Meindl, 1982; Scott et al. 1988). As it is explained in (Yoo et al. 2012), "intrinsic motivation, which refers to the motivation to do something due to inherent satisfaction, has been known as one critical factor that influence (s) the learning process. Thus, intrinsic motivation is an important motivator that affects learning, adaptation, and competencies and is necessary for human development. Intrinsic motivation would be a powerful source of behavioral drive when a person has opportunities to decide his or her behaviors autonomously. In contrast to intrinsic motivation, extrinsic motivation refers to doing something because it leads to a valued outcome such as improved job performance, pay, and promotions. Extrinsic motivators include anything related to work, such as promised rewards, praise, and deadlines." Moreover, for the measurement of motivational and cognitive variables in empirical research in this field mainly self-report questionnaires are used, but also occasionally use other instruments such as structured interviews (Zim-

merman and Pons, 1986, 1988, 1990) and open interviews (Pintrich and DeGroot, 1990). Thus, it is clear the motivation is fundamental and exist different methods to measure it.

We have chosen the PBL methodology because working together in small groups of students, through which the PBL process unfolds, refers to the social dimension of the constructivist view. Working collaboratively favors the activation of prior knowledge and stimulates attitude and motivation for learning. The motivational and emotional aspects are of particular relevance in this process, in particular the intrinsic motivation to learn is stimulated by novel tasks and appropriate difficulty, which promote creativity, higher-order thinking and curiosity of the learner, besides providing opportunities for choice and personal control. Thus, we have introduced one attractive topic in order to improve intrinsic motivation.

Motivation with the study of Patents

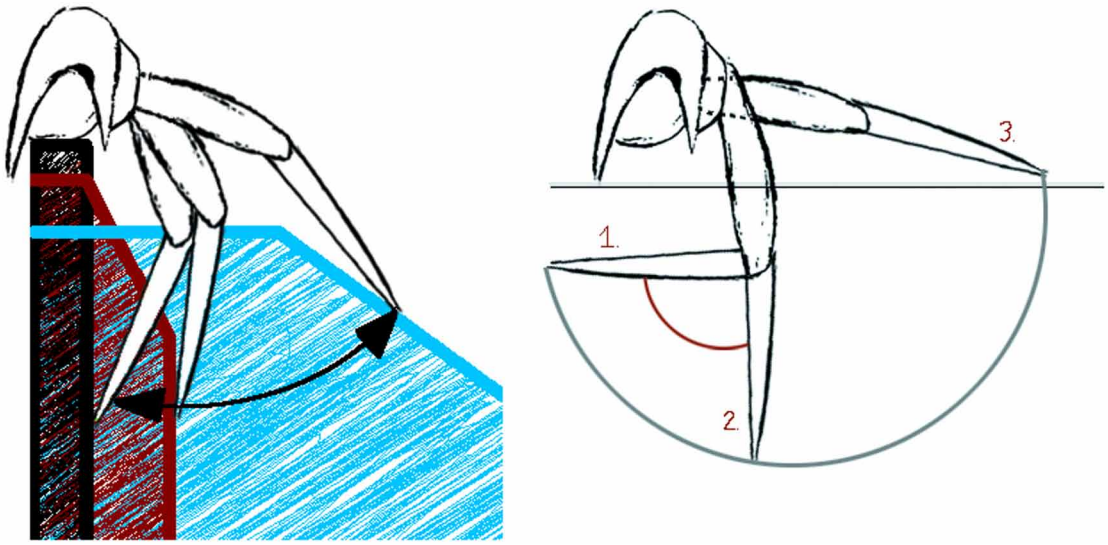
Project Approach

The number of student was 21. The course was organized in three different subprojects, so that it is necessary to use the knowledge gained in subproject 1 to do subproject 2 and the knowledge acquired in subprojects 1 and 2 to make the subproject 3. The initial two sessions of the course are devoted to an introduction to Intellectual Property. For each of the three subprojects that comprise the course, a theoretical section and a detailed instruction of the tasks to be done are provided, along with deliverables (slides of both parts are available online and a discussion forum is enabled in order to solve questions and concerns). The teachers provide also a timetable in which they are available to assist students. The projects are designed to be carried out individually. The students are required to deliver a report of their work for each project within pre-set dates.

Subproject 1: The subproject consists of adequately presenting the registration of a trademark. First, the teachers introduce the basic concepts about trademark and patent. Moreover, they explain the Nice Classification and its utility. Each student has to register the trademark in different classes according to the Nice Classification. In order to complete the subproject 1, the students have to go to the website of the Spanish Office of patents and trademarks where they can find all the information necessary for registration of a trademark. Finally, they should be aware of the different systems of trademark search to make sure that their brands are not previously recorded. The students are required to present the complete registration form of the trademark concerned.

Subproject 2: The subproject objective is to present the application for a patent, utility model or industrial design to the Spanish Patent and Trademark office. In order to facilitate the subproject completion, a student can invent any non-existing machine although it may be unreal or not realizable. For example, the teacher proposes to patent a “teleportation machine”. In the initial stage, the teachers introduce the concept of patent, showing the conditions of patentability, that is, the teacher must teach how to distinguish between what is patentable and what is not patentable. In addition, the teachers have to explain the difference between a patent, an industrial design and a utility model. Finally, the teachers explain the different parts that the document of one patent must contain. They also have to remark on the importance of the claims. In the next step, the students have to know the different public agencies that provide free help and advice on these issues. They will also have to learn for themselves what an acceptable report is. Finally, they should be aware of the different systems for patent search to make sure theirs inventions are not previously patented. For example, a student presents the following patent, “a web cam that can be used in all types of monitors”, and two illustrations inside this patent document are included (showed in Figure 1). The teacher must receive the complete registration of the concerned patent.

Figure 1. Examples of illustration of a patent presented by one student



Subproject 3: The project is focused on the extension of the patent or industrial design to different countries. Each student should choose a country in which they want to patent their invention. This is the hardest part for students because the contents in law aspects are greater. The students are required to present the completed registration form of the patent.

Project Motivation

This subsection provides the opinion of the students regarding the course expressed through an anonymous survey, at the end of the course. The survey shows the degree of satisfaction with the course and the developed projects: Table 1 shows the mean values for all students. The results of the survey include: 100% of the students rated the work on this course as very challenging, which motivates them to learn and they enjoyed more along the duration of the course than if they had dealt with a traditional methodology. Second, the student's opinion is very good, with all item scores above 4.

From the results of the survey, the following can be concluded: first, a good score in all items was achieved and second, the students valued the experience and the methodology used more than the skill learned. Moreover, the support of the teachers during the project was evaluated very positively by the students. Finally, the limitations of this study are related to the inability of student to communicate with the patent and trademark office, thus the teacher has to act as patent and trademark office. Another limitation, it is the lack of student imagination in order to think new developments that can be patentable.

Table 1. Students Survey Response (1 to 5)

	MEAN
Motivates me to learn	4.1
Encourages a better understanding.	4.2
It helps me learn more about the subject.	4.6
It helps me to correct misunderstandings.	4.4
Improving my skills.	4.1
It helps me relate the concepts of the subject with real-life situations.	4.8
They enjoyed more than conventional classes.	5
Learned more than standard classes	4.6
The methodology for the proposed project: Strongly Disagree (1) / Strongly Agree (5)	

Motivation with the Introduction of Ecology Issues

The introduction of motivation with ecology issues was done in several electives subject in the final year of engineering degree in University Center Mérida. There are two different extra-objectives (apart of the different learning outcomes of each subject), first extra-objective is to develop the skill of oral communications in the students and the second extra-objective is increases the motivation through the introduction of ecology issues.

Project Motivation

Starting from the famous sentence "You get what you assess" (Resnick & Resnick, 1992), i.e., the evaluation of the PBL methodology should be consequent with the strategy selected to follow during the learning process. For this reason, the students must be evaluated with the results obtained in the proposed problems. In order to introduce ecology issues in the subjects we are introduce different items in the rubric for the evaluation of the projects. The rubrics were done to the students, at the start of course. The rubric used in order to evaluate oral communications with 3 items related with green issues is shown in Table 2.

Evaluation of the Methodology and General Satisfaction

The methodological assessment of the entire project was carried out with a questionnaire that was previously validated by a board of experts in Science Education and Telematics Engineering from the University of Extremadura. The final questionnaire contains questions to assess the dimensions related to the students Satisfaction and the Methodology.

For the first dimension "Student satisfaction" two questions contained different items. The first

Table 2. Rubric for the Projects

	1	2	3	4
1. Exposure of the technical solution	The technical solutions is very poor	The technical solutions is poor in general, but some technical solution can be spotted	The technical solutions is good, but some question are unsolved	The technical solutions are very good
2. Speech Organization	Technical solution are exposed directly, without anticipating even number	Only the number of technical solution are expected	They anticipated and classified the arguments or ideas, but does not summarize during exposure scheme	They anticipated and classified the arguments or ideas, which are taken over and / or graphically support
3. Relevance and clarity of the argument	The arguments are not presented or not really related with the technical solution.	The arguments correspond to the technical solution but some of them are irrelevant or misunderstood	The arguments are relevant but they are briefly exposed or with low explicitness	The arguments are relevant and clearly expressed (specifying the assumptions, conclusions and justifications)
4. *Foundation of the argument*	No evidence offered nor premise or justification of the claims that are made	The arguments are based on opinion or particular experiences	Some arguments are based on evidence, but these are questionable.	Most of the arguments are based strictly on empirical evidence
5. Diversity and depth of the argument	Arguments are presented do not really answer the question for debate	The argument is simple and based on a single idea	Several arguments are relevant, but the storyline is simple (derived from a single premise) or is implied	Explains various complex arguments (which are derived from several premises or of a chain articulated explicit plot)

continued on following page

Table 2. Continued

	1	2	3	4
6. Green solutions	No solution is mentioned	They mention a "green solution" but they not able to relate to the project	They propose "green solutions" and relate this with the project	Proposes "green solutions" and quantifies the impact of the same in the project in terms of improving.
7. Questions, Comments and Rebuttal	Not interpellates to the other groups	The refutation is confusing or too vague	It identifies potential errors in the opposite exposure, but are not relevant or do not affect the storyline	Clearly identify the main biases or inconsistencies in the arguments of the opposing team.
8. Questions, Comments and Rebuttal about "Green solutions"	Not related to the other groups "Green solutions"	The refutation of "Green solutions" is confusing or too vague	It identifies potential errors in the opposite exposure of "Green solutions", but are not relevant or do not affect the storyline	Clearly identify the main biases or inconsistencies in the "Green solutions" of the opposing team.
9. Replica	No answers to most inquiries	The defense does not include the content of inquiries or based on mere repetition of arguments.	The defense explicitly responds to most inquiries, but is somehow unconvincing.	They consistently defended the position against all or almost all the counter-arguments..
10. Replica about green solution	No answers to most inquiries about "green solutions"	The defense does not include the content of inquiries about "green solutions" or based on mere repetition of arguments.	The defense explicitly responds to most inquiries about "green solutions", but is somehow unconvincing.	They consistently defended the position about "green solutions" against all or almost all the counter-arguments..
11. Conclusions	No conclusions are presented or are either irrelevant, inconsistent or confusing.	Relevant conclusions are exposed but not justified nor recapitulated	Summarizes the arguments and counter-arguments, but the findings are not clearly derived.	Based on a summary of the arguments and counter-arguments, relevant conclusions are formulated.
12. Conclusions about green solution	No conclusions are presented about "green solutions".	Relevant conclusions are exposed about "green solutions" but not justified nor recapitulated	Summarizes the arguments and counter-arguments about "green solutions", but the findings are not clearly derived.	Based on a summary of the arguments and counter-arguments about "green solutions", relevant conclusions are formulated.
13. Verbal language	The language is usually very poor or disrespectful	The language is respectful and courteous, but often vague and inarticulate	The language is respectful and accurate, just sometimes eloquent	The language is respectful and eloquent (incorporating rhetorical emphasis, humor, etc.).
14. Nonverbal Communication	Inappropriate gestures are adopted, reading the arguments or not looking at the interlocutor.	Appropriate gestures are adopted, but the voice is usually monotonous or without the appropriate volume.	Body posture, gaze, gestures, silences, volume, tone, etc.., are correct but non eloquent	Body posture, gaze, gestures, silences, volume, tone, etc.., Is correct and eloquent.
15. Rules for Participation	Interventions do not conform to the established time and / or turns not respected	Some interventions do not respect the rules and / or a team member assumes almost the entire partition.	Interventions respect the times and turns, but some of team members not are involved.	Interventions respect the times and turns with a balanced participation of team members.

one asks for the degree of satisfaction as a member of project and the second one is centered on the evolution of some skills from the point of view of the student. Specifically the question was "For you, working in this project was a……experience" with 6 different adjectives (items), graded in a Likert scale. The results for this question are summarized in Figure 2a and the items are shown in Table 3. In this one, it is possible to see that most of the answers are grouped around the two most positive indicators "Very much" and "Quite a bit". It is noteworthy that in the item where the indicator "Very much" has been chosen the most is item 5 (Formative) closely followed by item 4 (Satisfying). Moreover, it is notable that only in the case of item 2 (Stimulating) are there some answers in the indicator "None" while in the rest of the items this response was not chosen. From these results, it several conclusions can be made. For example, the students think that through the PBL project, they have learnt a lot and that this experience has not been easy (item 3 Effortless).

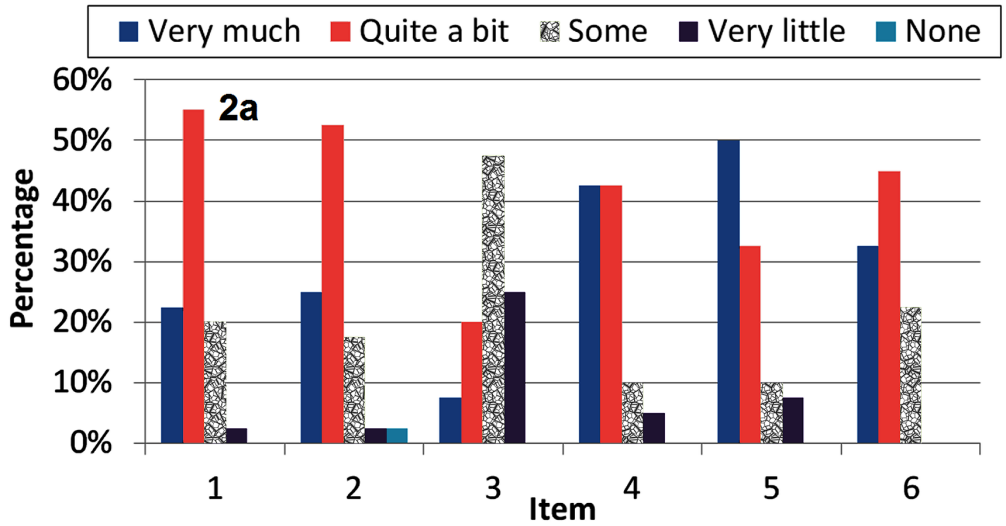
The results for the second question are illustrated in Figure 2b, a summary of how they perceived their evolution from their own point of view before and after carrying out the PBL experience is shown. In all cases there has been a significant increase in the level of self-perception of acquisition in different skills such as the degree of independence and the degree of competitiveness, but especially noteworthy is the increase in the degree of knowledge of the subject studied. This good by due to the fact that participation in PBL obliges the students mentally relate and organize concepts that, although they had been explained in class, were not consolidated learning for most students. Therefore applying this knowledge in a real situation meant developing and deepening their knowledge of the material.

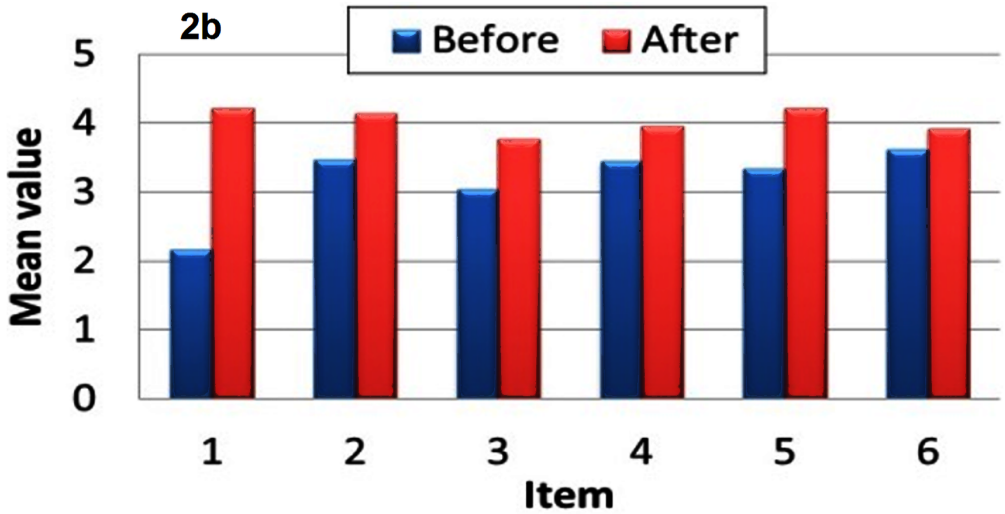
In the category "Methodology" up to 9 different items have been analyzed, which can be seen in the Table 3. From this category, the survey tries to extract the opinion of students about the methodology implemented. Only, in the case of item 7, which relates the contents of the subject to real life, only a small percentage chose "strongly disagree". Also in the case of the choice "Disagree" this research team needs to think about why in item 9, which measures the relationship between traditional classes and those using PBL there may be a small but illustrative number of students who doubt that they learn more in these kind of classes. Anyway, as it is possible to see in the Figure 2c, a considerable majority of students have chosen both "Strongly agree" and "Agree" for all 9 items, clearly highlighting item 8 "I

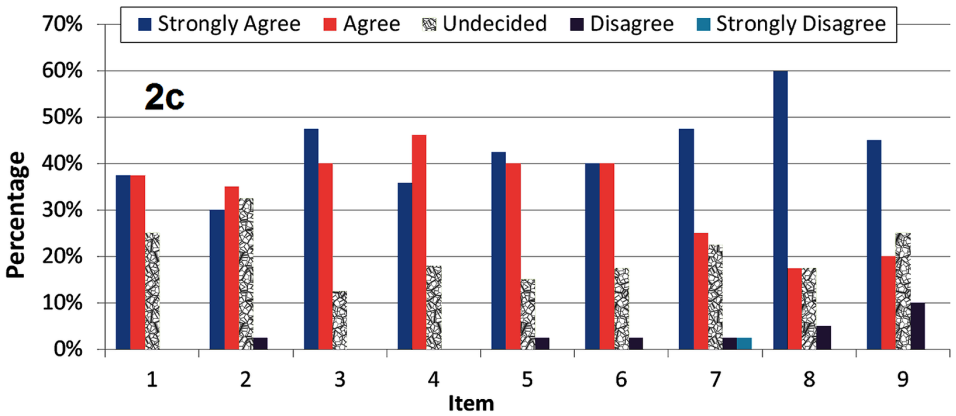
Table 3. Items from Figure 2

Item from Figure 2a	Item from Figure 2b	Item from Figure 2c
1. Enjoyable	1. Degree of knowledge of the subject studied	1. It motivates me to learn
2. Stimulating	2. Degree of confidence in the material	2. Promotes a better understanding
3. Effortless	3. Degree of flexibility of thinking	3. It helps me to deepen my knowledge of the subject
4. Satisfying	4. Degree of independence	4. It helps to correct misunderstandings
5. Formative	5. Degree of competition	5. I am encouraged to think
6. Creative	6. Degree of enthusiasm	6. It makes me improve my skills
		7. It helps me to relate the concepts of the course to real life situations
		8. I enjoy it more than with conventional classes
		9. I learn more than with conventional classes

Figure 2. (a) Review of the degree of satisfaction as a member or member of the project; (b) Degree of student satisfaction at start and the end of the project in some attitudes and skills; (c) General assessment of the methodology used







enjoy this class more than conventional classes". Finally, we would like to highlight some of the most significant comments and especially those most repeated by the students in response to the question: "what do you like most about the PBL project?" Examples of response were "Teamwork and solutions provided by my colleagues" and "The teamwork, the feeling that the whole group brings something". Response to the question: "what should improve in the project?" included, "less theory and more time to practice" and "Doing shorter lab practices, in order to do more".

Finally, the last question was regarding their overall opinion of the project and the results were the following: 17% extremely satisfied, 67% very satisfied, 13% moderately satisfied, 3% slightly satisfied and 0% not at all satisfied. These results are extraordinary, from our point of view, even more so given that the material covered dealt with was not especially appealing for the students when taught using a traditional approach.

MOTIVATIONAL ANALYSIS IN TWO DIFFERENT SUBJECTS IN TELEMATICS ENGINEERING

It is known that the practical implementation improves students' motivations. The following approach is to try knowing what kind of practical implementations are the best options in order to motivate the students. For example, what motivates more the student, with a long and complex practice that comprise all or with several small practices with one short goal at each practice? One opinion for the duration of the practical can be found in the conclusions of Mok (2012) "On the whole, students prefer differentiated lab exercises to traditional "one size fits all" ones". However other studies as Jung (2013) explain that students are very motivated with a big real experimental project. Thus, more investigations are needed.

We also must know when students are more motivated, at the beginning, during the course or at the end of the course. Another factor that influences student motivation is the tool that works to develop practical, is not the same motivation using a computer simulator or building an antenna, for example. Moreover the skills required are different and so are different skills they develop. It is important to know which tools or activities motivated more to students. Thus, it is desirable know when occur the lower motivation in students in order to introduce new motivations because it is tested that with an improvement on the motivation, it is produced an improvement on the learning.

Motivation has been analyzed in the laboratories of two different courses that implement a similar methodology but with slight differences, all laboratories are practical as it is known that practical implementations improve student motivation. The differences in the laboratories are the duration and the structure. The practices are also different from each other in the tools used to perform them, although some of them are repeated. To get feedback on student motivation anonymous surveys were conducted at the end of the course in the different subjects.

Motivation in Subject 1: Wireless Network

The subject of wireless networks is an elective subject in the final year of engineering degree in University Center Mérida. The objectives of this course are learning concepts related to wireless and mobile networks. The laboratory is organized into 7 different experiments of short duration. For each of the seven experiments that comprise the laboratory-course, a theoretical section (with sessions of 2 hours) and a detailed instruction of the tasks to be done are provided, along with deliverables (slides of both parts are available online and a discussion forum is enabled in order to solve questions and doubts). The laboratory sessions are based on an ubiquitous learning methodology in which students can conduct the experiment at any time and any place, but the teachers have a

schedule during which they are available to solve doubts in person. The experiments are designed to be carried out in groups of two or three students. The students are required to deliver a report of their work for each experiment within a fixed timetable. At the end of the term, a final mandatory exam is evaluates their learning outcomes.

In the first part of the survey students were asked about the methods and tools used, distinguished between two different ways, first if these methodologies were adequate for learning and second if these methodologies had motivated them to learn. The questions can be seen in Table 4 with the average of the results obtained and also it is shown in Figure 3.

The results show a good perception of the students in both motivation and learning, this is because a very practical methodology used. It is important to note that the best results in terms of motivation and learning are given for method 3, ie, learning through mobile. It is also important to observe how the students are less motivated when conducting activities that could say more daily (4, 5 and 7) such as the realization of memories but they are still thinking that these activities are useful for their learning. Further study it is also needed to see the correlation between motivation and learning. In the second part of the survey the students were asked by the practice structure, the results, it is shown in Table 5 and Figure 4.

It is observed that students are much more motivated to practice short than long practices, as seen in the results of the questions 3.3 and 3.4. It should also be noted as motivation increases over time in real projects, as reflected in the question 4.2. Finally, we asked to the student about general perception of the subject. These results is show in Table 6 and Figure 5

The student's perceptions are good in general with all item above 3.5 out of a maximum of 5.

Table 4. Evaluation of learning methodologies

	Mean Scores
1. Asses of methodologies in order to obtain a meaningful learning. (Students have meaningful learning or not)	
1.1 I consider that the use of commercial software has favored the learning.	4.23
1.2 I consider that the use of on-line software has favored the learning.	3.90
1.3 I consider that the use of mobile applications has favored the learning.	4.31
1.4 I consider that the oral public exposition has favored the learning.	3.87
1.5 I consider that the elaboration of practice reports has favored the learning.	4.08
1.6 I consider that the elaboration real-life project has favored the learning.	4.31
1.7 I consider that the performing of the calculations independently has favored the learning.	3.61
2. Analysis of methodologies in order to obtain the motivation on the students. (Student are motivated or not)	
2.1 I consider that the use of commercial software has motivated me.	4.05
2.2 I consider that the use of on-line software has motivated me.	3.58
2.3 I consider that the use of mobile applications has motivated me.	4.44
2.4 I consider that the oral public exposition has motivated me.	3.28
2.5 I consider that the elaboration of practice reports has motivated me.	2.79
2.6 I consider that the elaboration real-life project has motivated me.	3.48
2.7 I consider that the performing of the calculations independently has motivated me.	2.45

Figure 3. Learning and Motivation results in subject 1

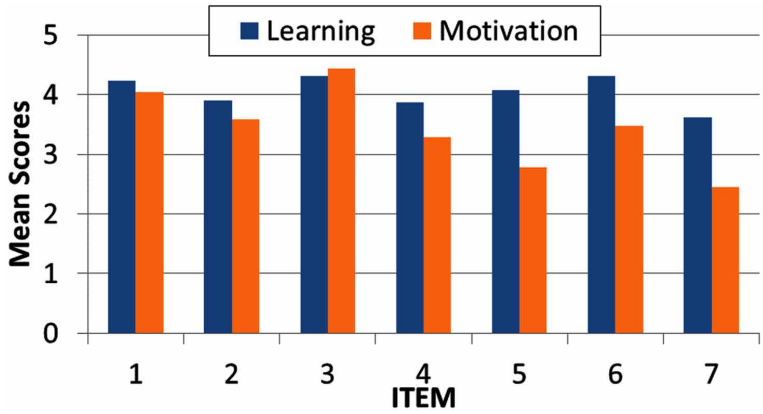


Table 5. Evaluation of practice structure in subject 1

	Mean Scores
3. Practice structure (size and duration of practice)	
3.1 I liked running consecutive practice on the same subject.	3.51
3.2 I consider that you have learned more with consecutive practices performing on the same subject.	4.08
3.3 Instead of performing consecutive practice on the same subject, you'd have preferred a single practice that encompasses everything.	1.51
3.4 Instead of performing consecutive practice on the same subject, do you think you would have learned more in one practice that encompasses everything?	1.73
4. **Practice structure II (When the student are more motivated)** The moment you more motivated for practices ... has been. **1** Before You Start; **2** In the beginning; **3** half of embodiment; **4** When I was finishing **5** At the end	
4.1 Commercial software (RF3D Wifi Planner).	2.93
4.2 Real projects	3.56
4.3 Applications on mobile.	2.81
4.4 Software on-line (Aerohive).	2.54
4.5 Calculations autonomously	2.82

Figure 4. Learning and Motivation results in subject 1

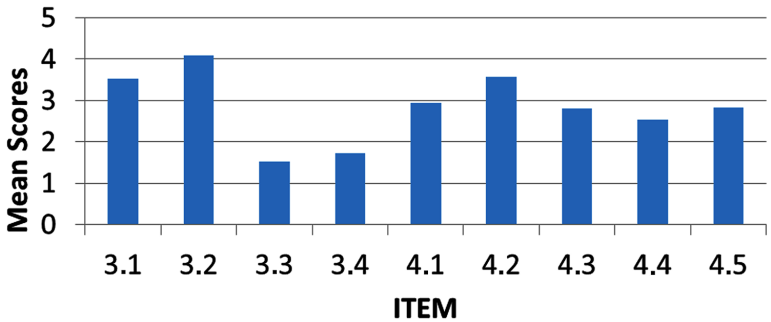


Table 6. General perception of the practices in subject 1

	Mean Scores
5. General perception of the practices	
5.1 I liked the practices.	3.74
5.2 You have been motivated with the practices.	3.69
5.3 You think that practices are well designed.	3.27
5.4 You think you've learned making practices	4.05
5.5 Teachers opinions	4.08

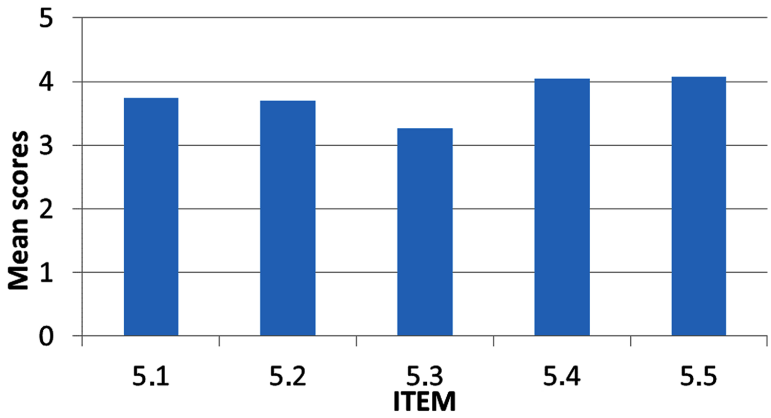
The lower scores are in the point 5.3 when the students are asked if the practices are well designed. This can be due the numerous numbers of little practices (up to 7).

Motivation in Subject 2: Telecommunications and Projects

The number of student was 26. The subject of Telecommunications and Projects is an elective course that is taught in the fourth year of the degree in Telematics Engineering at the University Center of Merida. This subject is structured in similar way to the subject 1 with different short practices with different instructional methods. The differences are the number of practices (5 or 7) and in this second subject, it not used e-learning nor m-learning. In order to evaluated the motivation a very similar surveys has been done to the students.

After graduation, the following year, students will develop their knowledge in the development of their profession. Among the many job opportunities for the degree, one of them is the free exercise of the profession. So, right, of the many possible Telecommunication projects, to be undertaken by graduates in Telematics Engineering, one of the most common is the Common Telecommunications Infrastructure (ICT). These projects consist in develop the infrastructure of different building. Believe that the most intuitive is to start with the known. Thus, the most common site for all students is the administrative building of the University Center of Merida, in which they study, and work to be performed on this center. The laboratory is organized into 5 different experiments of short duration. For each of the five experiments that comprise the laboratory-course, a theoretical section (with sessions of 2 hours) and a detailed instruction of the tasks to be done are provided, along with deliverables (slides of both parts are available online and a discussion forum is enabled in order to solve questions and doubts). The experiments are designed to be carried out in groups of two or three students. The students are

Figure 5. General perception of the practices in subject 1



required to deliver a report of their work for each experiment within a fixed timetable. At the end of the term, a final mandatory exam is evaluates their learning outcomes.

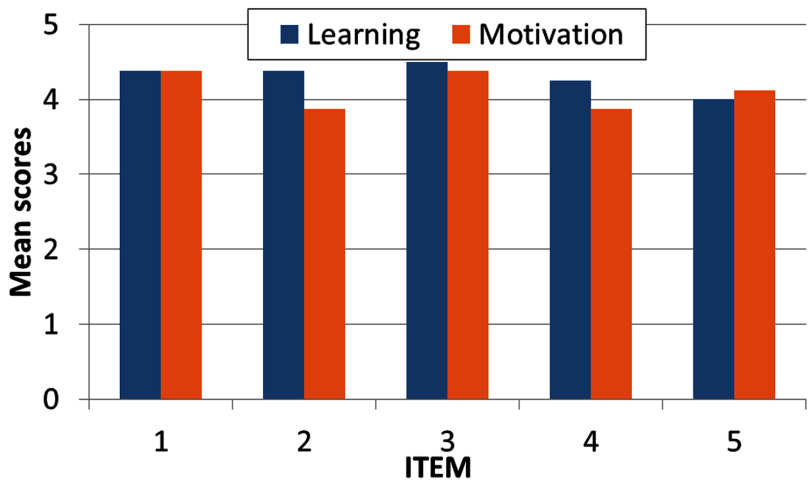
In the first part of the survey students were asked about the methods and tools used, distinguished between two different ways, first if these methodologies were adequate for learning and second if these methodologies had motivated them to learn. The questions can be seen in Table 7 with the average of the results obtained and also it is shown in Figure 6.

The results show a good perception of the students in both motivation and learning, with all item above 3.5 out of a maximum of 5. It is important to note that not exits big differences between the different instructional methods used. It is also important to observe that scores of moti-

Table 7. Evaluation of learning methodologies

	Mean Scores
1. Asses of methodologies in order to obtain a meaningful learning. (Students have meaningful learning or not)	
1.1 I consider that the use of commercial software has favored the learning.	4.38
1.2 I consider that the oral public exposition has favored the learning.	4.38
1.3 I consider that the elaboration of practice reports has favored the learning.	4.50
1.4 I consider that the elaboration real-life project has favored the learning.	4.25
1.5 I consider that the performing of the calculations independently has favored the learning.	4.00
2. Analysis of methodologies in order to obtain the motivation on the students. (Student are motivated or not)	
2.1 I consider that the use of commercial software has motivated me.	4.38
2.2 I consider that the oral public exposition has motivated me.	3.88
2.3 I consider that the elaboration of practice reports has motivated me.	4.38
2.4 I consider that the elaboration real-life project has motivated me.	3.88
2.5 I consider that the performing of the calculations independently has motivated me.	4.13

Figure 6. Learning and Motivation results in subject 2



vation and learning is very similar. In the second part of the survey the students were asked by the practice structure, the results, it is shown in Table 8 and Figure 7.

It is observed that students are much more motivated to practice short than long practices, as seen in the results of the questions 3.3 and 3.4, this results are agree with the results of subject 1. It should also be noted as motivation is similar increases over time in real projects, as reflected in the question 4.2. Finally, we asked to the student about general perceptions of the subject. These results are show in Table 9 and Figure 8.

The student's perceptions are very good in general with all item above 4 out of a maximum of 5. This demonstrates that the structuration of the laboratory with different short practices is adequate.

Table 8. Evaluation of practice structure

	Mean Scores
3. Practice structure	
3.1 I liked running consecutive practice on the same subject.	4.50
3.2 I consider that you have learned more with consecutive practices performing on the same subject.	4.38
3.3 Instead of performing consecutive practice on the same subject, you'd have preferred a single practice that encompasses everything.	1.73
3.4 Instead of performing consecutive practice on the same subject, do you think you would have learned more in one practice that encompasses everything.	1.73
4. Practice structure II (When the student are more motivated) The moment you more motivated for practices ... has been. **1** Before You Start; **2** In the beginning; **3** half of embodiment; **4** When I was finishing **5** At the end	
4.1 Commercial software.	3.63
4.2 Real projects	3.50
4.3 Applications on mobile.	3.50
4.4 Software on-line	2.75
4.5 Calculations autonomously	3.13

Figure 7. Learning and Motivation results in subject 2

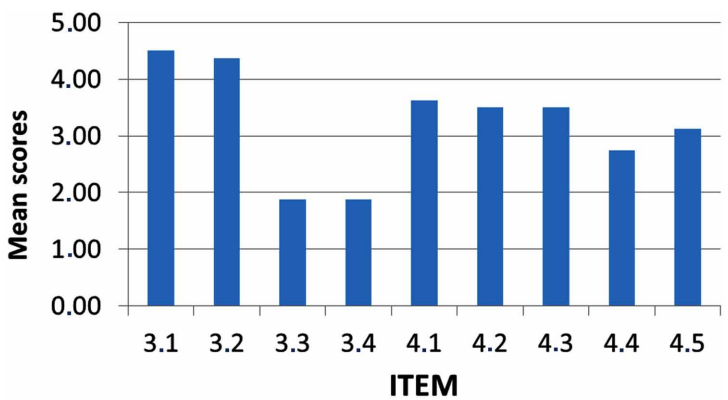


Table 9. Evaluation of general perception of the subject

	Mean Scores
5. General perception of the practices	
5.1 I liked the practices.	4.38
5.2 You have been motivated with the practices.	4.25
5.3 You think that practices are well designed.	4.25
5.4 You think you've learned making practices	4.38
5.5 Teachers opinions	4.75

DISCUSSION

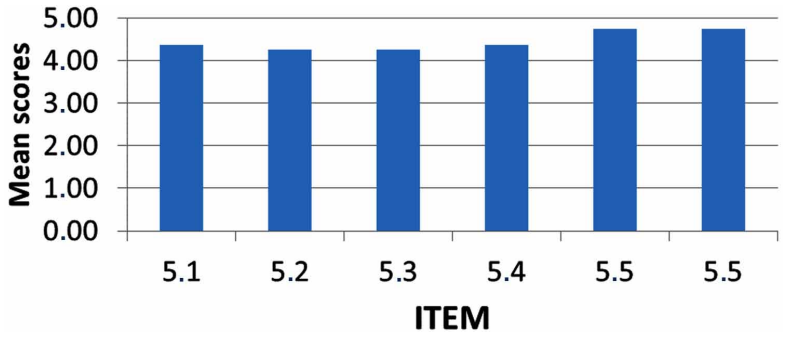
In this chapter we have seen how it has increased intrinsic motivation on the students introducing a topic that captures their attention, for example, in response to the question "I enjoy it more than with conventional classes" all students got the highest score when the topic of patents was introduced. Moreover, with the introduction of the second attractive topic the students response was in the same way with over 60% of students responding with maximum score and any student below the average. Also noteworthy, it is that the second question with top marks obtained in the introduction of a topic is "It helps me to relate the concepts of the course to real life situations". Thus, the students think that the introduction of these topics facilitates them the transition University-Work. As a limitation, it is observed the difference perception of students between enjoy more and learn more when this wide demonstrated that better motivation drive to learn more. Therefore we can say that the introduction of a topic to increase intrinsic motivation has been worked reasonably well. A key issue, it is the choice of topic to introduce and how this topic increases the intrinsic motivation. With regard to the limitations provided by this technique in order to improve the motivation, it is not easy to find a crosscutting issue that sparks the interest of the student.

Regarding the analysis of the different methodologies, the worst result obtained for the traditional methodologies in the case of the subject 2 with a big difference in perception between what students think and learn what motivates them, therefore the realizer this methodology is a lack of intrinsic motivation is identified. However, when mobile devices are used this intrinsic motivation is triggered.

CONCLUSION

In this chapter, it have been review the literature about motivation in engineering education showing different methodologies that it have been used by others authors. Then, it has been presented different studies developed in our University. It has been studied the motivation of students to

Figure 8. General perceptions of the practices in subject 2



cope with different types of practices. Also, it is studied the impact of introduce several transversal attractive topics in the subject in order to increase the student's motivation. We have found that the introduction of different transversal topic (ecology, patents) increase the motivations as it is demonstrated by teachers perceptions and the results of the surveys. We have found that students enjoy more with small practices, and a short-term goal, than with large practices. It has been observed that the use of methodologies such as m-learning motivate students, this may be because the student have a high technological profile (students to telematics engineer). We have also found that students are more motivated at the end of practices involving real projects such as observed in the survey. Finally the course that best value obtained was the second involving a very real problem.

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KEY TERMS AND DEFINITIONS

Ecology Sustainability: The maintenance of the factors and practices that contribute to the quality of environment on a long-term basis.

E-Learning: Is the education and training over the Internet. This type of online education allows user interaction with the material using computers.

Green Design: Product design philosophy that treats environmental attributes as design objectives and not as constraints. It aims at incorporating those attributes without compromising performance, quality, functionality, and the useful life of the item.

M-Learning: Is the education and training over the mobile phone or other mobile device. This type of online education is a particular case of e-learning.

Motivation: Internal and external factors that stimulate desire and energy in people to be continually interested and committed to a job, role or subject, or to make an effort to attain a goal.

Patent: It is an invention that need be protected in order to be exploited economically.

Problem-Based Learning: It is a methodology on education that motivate to the student. This methodology proposes several real life problems to be solved by students.

Rubric: It is a tool designed in order to assess different skill.

Telematics Engineering: An engineering degree that is centered in the study of informatics and telecommunications issues.

Chapter 10
MOOCs for Enhancing Engineering Education

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ABSTRACT

All over the world, thousands of engineering institutions offer conventional engineering education. However, the quality of education, is a matter of concern. MOOCs (Massive Open Online Courses) permit learners to access and benefit from the teaching by renowned professors. MOOCs offer an unprecedented opportunity to revitalize education. These cause complete dis-intermediation of the university system, making them very affordable; however, they have several shortcomings in their present form. Students enrolling for a MOOC still have to conventionally study the subject for their degree. Complete absence of physical group activities in a class room under a teacher's mentoring, is another serious issue. Conduct of practical sessions in laboratories is an important aspect of engineering education, for which MOOCs offer no alternative. This chapter reviews the state-of-the-art of MOOCs in engineering education and provides suggestions as to how MOOCs can be effectively utilized for enhancing engineering education.

INTRODUCTION

Around the globe, educational institutions offering engineering education vary in their level of control over the program of study, syllabus, and examinations. This situation is prevalent in developing world where most engineering colleges are affiliated to different universities to offer conventional engineering education. In this case, universities exercise rigid control over curriculum and examination. Teachers in these colleges only do teaching with little room of innovation in learning.

The MOOC (Massive Open Online Course) is the latest buzzword in distance education. MOOC brings together high quality 'Ivy League' providers, online education and a low-cost model. MOOCs align with the approaches to teaching and learning advocated by the Kronberg Declaration (UNESCO, 2007). In these approaches, learners play an ever more active role in knowledge acquisition and sharing with the role of teachers and instructors decreasing. The basic design of individual MOOCs may not have moved too far beyond traditional pedagogical approaches. However, the concept of MOOC, being largely

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lecture-based in format, is learner-centered. MOOCs liberate students to access and engage with education. In the past six years the number of MOOCs being offered by universities around the world has expanded into the hundreds. Three MOOC platforms are leading the race, Coursera, Udacity and EdX, and all three are associated with the highest ranking US universities. By September 2013, Coursera offered over 403 courses from 86 different universities and institutions and had over 4.6 million registered users. EdX represents a partnership between Harvard and MIT, while Udacity, like Coursera, started at Stanford.

A MOOC aims to have large-scale interactive participation and open free access via the Internet. Rather than simply making resources or courseware freely available, MOOCs create the opportunity for learners to take part in learning activities, interact with other learners and connect with course instructors, albeit in a limited sense. Generally MOOCs have no fees, prerequisite qualifications, formal accreditation or predefined levels of participation (Liyanagunawardena et al, 2013). Taking part is voluntary and depends on the interest and motivation of the learner.

The term MOOC was coined during a course on 'Connectivism and Connective Knowledge' run by the University of Manitoba in Canada in 2008. The course design was based on 'connectivism'. Connectivism is an approach to networked learning advocated by the organizers of the 'Connectivism and Connective Knowledge' course, George Siemens and Stephen Downes (Littlejohn, 2013). As Kop (2011) describes it: "Connectivists advocate a learning organization whereby there is not a body of knowledge to be transferred from educator to learner...instead, knowledge is distributed across the Web, and people's engagement with it constitutes learning" (p.20). The MOOCs that have emerged from this philosophy of learning tend to be open in nature, non-hierarchical and largely learner-defined (Littlejohn, 2013).

Even in the short time of MOOCs' existence, however, a second type of course has emerged, with a distinct pedagogical outlook. The original MOOCs based on the connectivist approach, and now known as cMOOCs, have been overshadowed by their 'instructivist' cousin, known as the xMOOC. As Littlejohn (2013) put it, in xMOOCs "learning goals are predefined by an instructor, learning pathways structured by environment and learners have limited interactions with other learners" (p3).

MOOCs offer an unprecedented opportunity to revitalize education by complete dis-intermediation of the university system: making quality learning affordable and accessible. While MOOCs have several shortcomings in their present form, these shortcomings are fast diminishing due to advancements in the technology. Conduct of practical sessions in laboratories is an important aspect of engineering education, for which MOOCs have started to offer alternative through virtual labs integration in the MOOC platform. A flipped-class room model has been suggested for MOOCs to address the issue of absence of physical group activities.

In USA, a very small segment of higher education institutions (2.6%) were experimenting with MOOCs in 2013. A somewhat larger number of institutions (9.4%) were planning for using MOOCs. Most institutions (55.4%) remain undecided about MOOCs and 32.7% of institutions had no plans for a MOOC. While unconvinced that MOOCs represent a sustainable method for offering online courses, academic leaders believed MOOCs provide an important means for institutions to learn about online pedagogy. While not concerned about MOOC instruction being accepted in the workplace, academic leaders were suspicious that credentials for MOOC completion will cause confusion about higher education degrees (I. Elaine Allen & Je! Seaman, 2013).

ENGINEERING EDUCATION AND ROLE OF MOOCs

There is growing literature on MOOCs, focusing on challenges and trends, pedagogic approaches, technological issues and case studies. To date, the evidence emerging from this research strongly suggests that compared to the massive number of enrolments that many courses have secured, completion numbers are underwhelming.

Statistics from USA shows that more than ½ of students who begin in engineering (53%) leave before receiving their degree and approximately half of the attrition occurs during the first year (Science and Engineering Education Indicators, 2014). This attrition is greater for students from underrepresented backgrounds. We also see less number of students coming into engineering from other fields, a rigid and inflexible engineering curriculum, and prevalence of "Middle year" syndrome with high attrition (due to structure of the educational experience and the culture of the discipline). One the other hand we see an increasing enrolment of engineering students in large developing countries, such as India. As these countries move to increase their gross enrolment ratio in coming years, the need for quality teachers will increase, and the supply-demand gap will widen.

A paper from Duke University describing the development and delivery of a Bioelectricity MOOC reveals that only 4.41% of enrolled learners were still engaged after four weeks, as measured by scoring greater than zero in a online quiz (Belanger & Thornton, 2013). According to Daniel (2012), an MIT Circuits and Electronics MOOC started with 155,000 registrations, had 23,000 attempt the first problem (14.8%) and just 7,157 (4.6% of registered) pass the course. Across a range of courses, the number accessing the course sites, even in the first week, is often a minority of those registered, and those actively engaged with the course content in the form of completing tasks, quizzes or posting on forums is a smaller number again.

What becomes evident is that while the extent of MOOC attrition is unprecedented, the problem is not new in distance learning. Simpson (2004) reports that within the Open University (OU), "The proportion of students who submit assignments on a typical course is about 60% of the starters for the first assignment, falling to around 40–50% for later assignments" (p.80). In their examination of learner attrition in online programs, Bernard et al (2004) identified 'Readiness for online learning' as being a key element influencing whether an individual would complete the course of study. Such readiness, they proposed, included four dimensions: IT skills; organizational and cognitive strategies; attitudes to online learning; and interaction with tutors and classmates. These factors are also likely to be significant in relation to MOOCs. In addition, given that one of the defining characteristics of MOOCs to date has been unrestricted admission, students from diverse backgrounds with a vast range of academic and life circumstances are likely to sign up. Couple this with the no-stakes nature of the courses and it is not hard to see why attrition rates have been so high.

The objective of this chapter is to explore how MOOCs can be effectively utilized for enhancing engineering education.

MOOCs and Quality of Engineering Education

Similar to any learning innovation, MOOCs in engineering gained a lot of interest and hopes in the beginning. MOOCs looked promising and people hoped that MOOCs as a new approach to engineering education would bring many radical

changes in engineering education. With the passage of time, the focus must change to evaluate if those promises can be fulfilled in the long term and on a sustainable basis.

Measuring quality of course is important. Because, to a large extent, we can verify that aims and intentions have been met. These aims and intentions may vary from institution to institutions. Some institutions may aim to have a sufficient number of students and upheld the institution's reputation. While the teacher in charge of the course may have similar aims he/she also has personal aims and objectives. Student's aim may be to learn what the teacher taught, pass the course, enjoy the experience and gain useful skills. Therefore, quality measures and procedures that monitor these aims and objectives need to be developed. These quality measures may include student course completion rate, level of student satisfaction, and scores of external assessment of course content. Many of these intentions are altered in a MOOC. This alteration can either be radically or subtle. At present, intentions of institutions are not entirely clear. It is unclear whether engineering institutions want MOOCs to attract more formal students, to provide a public good, or just to make more money. Engineering educators may experiment with MOOCs to experiment with curriculum or pedagogy, to gain personal reputation, or personal development.

Since MOOCs are still in their nascent stages of development, the aspect of quality in MOOCs has not been analyzed in depth. For every learning environment, quality is the condition that determines how effective and successful learning can take place. In engineering education, this aspect is more important. Starting from 1990's and continuing today, there has been a significant movement towards understanding the issues that may affect the quality of engineering education. Many universities around the world have been making major efforts to recognize the challenges faced by engineering education programs and to make changes to achieve what many call "Excellence in Engineering Education." With respect to MOOC quality, we need to answer some critical questions. These questions include: what are the real aims of MOOCs? Can we assess MOOCs quality the same way we assess quality of any defined university course with traditional degree awarding processes? Do we need to take into consideration different type of learning objectives for MOOC learners? Are MOOC learners mostly interested in small pieces of learning tailored to their needs that can fulfill their objectives? The critical questions regarding measuring quality of MOOCs include: what could be the possible dimensions of quality model for MOOC? What could be the quality assurance methods for MOOCs? To answer these questions, we must take into consideration some significant points.

First, there exist no clear definition of a MOOC. Many of them are not massive or open and some are not really even courses in the traditional sense. There exist diversity among MOOCs models such as open connectivist learning network model and traditional lecture-based model. Both models differ significantly and therefore the discussion of quality in MOOCs in general terms is difficult and depends on the type of MOOC being discussed. MOOCs lack one key quality factor i.e. the target group. Courses normally have a clear target group. The target group can be used to measure the success of course in meeting the needs of that group. MOOCs have no clear target group and everyone can join a MOOC. The MOOC participants vary greatly in their aims and objectives. In many cases, participants have no intention to complete the course. Assessing the quality of a course that means very different things to a diverse and very large population is very difficult.

Second, MOOCs, in general, offer free access to a collection of educational resources. Together, these resources form a progression which is linked logically. In this case, quality means the value and relevance of the resources and the way these resources are linked. Many MOOCs lack qualified tutoring or guidance. These MOOCs

only offer online areas for student communication and offer learning materials. The quality of these online areas can be assessed by assessing their functionality but a large part of activities going on in these areas are beyond he control of the organizers. MOOCs also provide "value-added" services on layers higher than layers on which course material is provided. It is possible that quality issues of MOOC lies in these services. If these value-added services are available at a price than these services can be more easily assessed and quality guidelines set up.

The rigidity of the university systems greatly impacts the quality of engineering education. This is the case in many developing countries. Teachers teach in individual colleges with strictly as per the prescribed syllabus. The changes in syllabus, if at all, takes place at a snail's pace. Teachers exercise no control over the syllabus and examination. Problem solving abilities, central to engineering education, do not get adequately tested at all. The ability to produce excellent engineers comes from the immense autonomy of the teacher, its responsible and creative use, and continuous experimentation with the process of teaching, learning, and testing. According to (Stephen Downes, 2013), there are four key success factors for MOOC to produce it intended outcomes and improve its quality. Similar success factors are applicable to MOOCs in engineering.

1. **Autonomy:** MOOCs participants interact with other participants based on their own goals and objectives, judgments and assessment of success. MOOC participants cooperate rather than collaborate. They exchange value and support each other but each pursue his/her own objectives depending on his/her own means and resources. Without autonomy, a MOOC is not able to adapt to the environment. Without autonym, participants will not be able express their unique point of view of the world to influence the course design. Rather, the participants would be forced to reflect the point of view of some organizer as to what their objectives should be, what they should learn, and is the measure of success. This aspect is especially important in engineering education because to keep the knowledge current, many engineering subjects needs quick changes in the syllabus, teaching strategies, and resources.
2. **Diversity:** Diversity is a natural consequence of autonomy. While diversity is generally defined in terms of language, ethnicity or culture, for MOOCs the diversity refers to a broad range of criteria, including location and time zone, technology of choice, pedagogy, and learning style. Some participants may experience the course as a series of lectures while some may view the course as project-based, creating artifacts and tangible products. Others may view the course as an opportunity for interaction rather than learning. Without diversity, it is very difficult to expect the possibility of emergence of a network having different states, or different types of organization. A non-diverse collection of entities can be overly reactive where a change in one can become a change in all. Any sort of complexity and learning requires diversity. Responding to the economic, social, and environmental challenges of the coming century will take more than increased number of engineers. It will require a more diverse population of engineers.
3. **Openness:** Openness refers to the idea that network contents are fluid and network boundaries are porous. In the context of MOOCs, it means that participants of the MOOC are not only free to join and leave the course at any time but also free to move in and out of course activities. Openness to perceptual input is an a priori condition for perception; a pre-requisite for learning. To determine what is good and what is bad we need perception of evil. Such experience can be obtained through openness to other

ideas, other cultures, other technologies, and other people. The free flow of people and information through a MOOC is as important as the organization of people participating in the MOOC. One negative aspect of openness is the absence of clear demarcation among participants and non-participants of MOOC. The MOOC represents a cluster of loosely associated participants, resources, and ideas. In connectivist model, lurkers can play equally important and valuable role as active participants because off-topic discussions are seen as valuable outcomes. With increased openness in engineering MOOCs, knowledge creation and teaching at each engineering program will be elevated by the efforts of individuals and groups all over the world. It will rapidly adapt to the changing learning styles of students and students from developing countries will benefit the most.

4. **Interactivity**: Interactivity refers to the idea that new learning is the result of connectedness and interactivity among MOOC participants. The new learning does not transmitted from few powerful participants. Rather, new learning emerges from the network of participants as a whole. Engineering students are more interested in the online courses if they can complete on-line and on-time several tasks. Interactive on-line materials and exercises can give to student more rapid feedback than when work is turned on to paper and the results and evaluation come back faster

MOOCs and Laboratory Experiments

Most engineering curriculum include laboratory practical sessions. In these hands-on sessions, students work on actual equipment, learn to make measurements through observations and readings, and increase their understanding of how various things work. Around the globe, these sessions are a crucial component of engineering education. Students learn real aspects of engineering in these sessions. Several MOOCs have been developed on topics that were already being taught as traditional face-to-face (F2F) classes: Statics, Dynamics, Circuits and Electronics, Physics 1, etc.

MOOCs model works well for many subjects. However, it falls short in the sciences and engineering domain where students need to conduct research experiments to support their study. Consequently, a major challenge for current MOOCs is how to design a framework that effectively supports large-scale, self-directed learning as well as self-organized experiments and research. To meet this need, Beihang University, in collaboration with Microsoft Research Asia, developed MOOR (Massive Open Online Research), a new cloud-based platform built on Microsoft Azure (Microsoft Research Connections, 2014). The MOOR platform consists of three major components:

- A course-specific virtual lab facility, which enables remote access to the devices needed for experiments
- Course-management middleware, which coordinates both the online course services and virtual lab services, such as lab reservations, resource allocations, and lab assignment grading
- The MOOR portal, which integrates the virtual lab functions into the online learning interface

MOOR is powered by Microsoft Azure. MOOR is able to push high-quality video streams to tens of thousands of students simultaneously through a cloud-based, elastic video streaming service. In addition, MOOR allows customization of the software environment of the virtual labs. Instructors can enable their students to run course-specific simulations and logic verifications and to access virtual lab equipment.

Lambertus Hesselink, an engineering professor at Stanford University, developed a way for students in MOOCs to conduct virtual lab

experiments called an "iLab". Previously, Hesselink developed technology that allowed students to control real, physical lab equipment through the Internet—which worked remotely, but didn't easily scale up. This new iLab is completely virtual, scalable, and cost-friendly. As an example, to build a diffraction experiment, Hesselink's team rigged a camera to take snapshots of every possible permutation of the experiment. So when students interact with the controls, they see a video of what would have happened if they'd done the physical experiment. As The Boston Globe (2014) explains, "It's something like a "choose your own adventure" version of a lab experiment." (p.1) .This sort of virtual experiment is inexpensive, can be created in just a few hours and can be used by as many students as needed at once. This would make iLab a good bet for cash-strapped classrooms (Heitin, 2014).

Michael Schatz, a physics professor at Georgia Institute of Technology, set out to transform the lab experiment through a MOOC. In the course "Your World is Your Lab," offered on Coursera, students did the normal MOOC stuff, like watch videos, take exams, and use discussion boards, but they also did lab experiments, which counted for 65 percent of their grade. In the course labs, students used their phones to record motion, use open-source software to analyze that motion, and then wrote computational models to reproduce it (David Blake, 2014).

MOOCs and Group Activities

Group activities in a cooperative learning environment can help improve engineering student learning while developing essential teamwork, communication, and leadership skills. The students can improve their understanding of the course material because of the interaction of the students' views, the need to listen and to express ideas, and the opportunity to see other ideas. The students can accomplish more and understand concepts better than by working alone (McDonald, 1995).

Absence of physical group activities is one significant shortcoming of MOOCs. Several experiments with flipped or blended classes that have been enabled by MOOCs or by the experience and technology developed to support MOOCs. The most important aspect of MOOC is the formation of sub-networks. These sub-networks are created out of the large network of MOOC participants. These sub-networks can be formed around geography, language, or some other attribute that draws individuals together. These sub-networks cannot be formed in MOOCs where number of participants is low. With large number of students, say 5,000, new configurations are possible. MOOC offerings need to include problem based learning and group learning. This task is not easy given very high drop-out rated of MOOCs where drop-out rate can reach as high as 90%.

In MOOCs with large number of participants, quality of learning can be improved by creating a model that allows rapid creation/dissolution of groups. These groups can be either highly cohesive social groups or low cohesive social groups. In highly cohesive social groups, participants in group problem salving and quests. The low cohesive groups are formed on spot and dissolved once a member leaves. Low cohesive groups are worth considering for MOOCs (Gsiemens, 2013). For example, if MOOC provider offers a course due to high drop-out rate pre-planned group activities will most probably not work well. Instead, the system can be designed so that student is automatically placed in a queue when he/she gets registered for a MOOC. When enough students get registered for the MOOC, system will put these students into a group work and students will complete the course activity. This low cohesive group can be transformed into a highly-cohesive group if the students like working together. Students can then schedule times to work online together. If that's not the case, the groups is dissolved on completion of course activity. Students will be put into an entirely new groups of leaners for the next course activity. This group work experience can

be further extended by assigning different roles to the participants in the group. Each role would be vital to achieve a particular challenge. In case of non-cooperation among group members the sharing of knowledge and skills wouldn't be possible and problem wouldn't be solved. This group format will likely run for longer periods of time and may be most successful for groups that have worked together in the past. One side-effect of this group extension is that the group participants must be very passionate about their learning. For most MOOCs this is not the case. While learners may be passionate about learning they may not be passionate about participating in a group/community. MOOC providers should focus on building both courses and communities. While students should be allowed to start off seeking a course but then these students should be encouraged to join a group/community. A very simple starting point could be attaching a Facebook group to the MOOC. The ideal solution will involve formation of short-term groups initially and then gradually lead them to longer-lasting groups. These longer-lasting groups have tremendous potential to positively influence learning of those participants who are well versed on the skills and knowledge shared by the group. If someone joins a group and realizes that he/she lacks the skills and knowledge shared by the group, he/she can be provided a natural pathway toward more of a course experience. These learners can progress by first starting in the large community and then find a sub-group closer to their skill level.

Collaborative learning is important in MOOCs. In designing MOOCs, many MOOC providers encourage and endorse the natural formation of groups as part of their approach to the participation. MOOC providers are exploring early opportunities for participant groupings in social networks (e.g. LinkedIn). MOOC providers invite learners to take part in the development of course model, interactions and communications. Armed with learners' achievements statistics (such as completion rate and involvement level) MOOC providers try to build groups out of people who already proved their commitment to learn. The exchange of learners' achievements statistics among MOOC providers would be advantageous to such a group-formation principles.

In 2012, Stanford professor Amin Saberi and PhD student Farnaz Ronaghi created a project called Venture Lab, now called NovoEd. NOvoEd offered free online courses and offered a platform focused on collaboration and project and team-based learning. Upon signing up, the NovoEd system assigned the students to a group of 10 or fewer students. This assignment was based on student's location or similar interests and backgrounds. During the course of study, students ranked each other and these rankings were compiled at the end of the course to form a student's "Team Score". The other students used this team score when making decisions to form groups on their own. The idea is to create a dynamic in which students are accountable to their peers and fee a bit of social pressure to perform to keep their rankings up. That would ultimately result in a learning experience that is more engaging. Many MOOC platforms suffer from high attrition rates. NovoEd hoped to solve that problem by creating a social incentive system that aims to keep students continue in the course (Empson, 2013).

MOOCs and Accreditation

Whether MOOCs can replace, reinforce or undermine the traditional university model would become irrelevant if the sophisticated and high-tech learning content provided by MOOCs cannot be transformed into credible accreditations acceptable for employers. Recent figures show that MOOCs are living up to the massive tag. More than 10 million MOOC learners participated in 1533 MOOCs around the globe. In order to gain real success, MOOCs need to provide similar commitment to measure the impact as any other traditional university learning initiative. The commitment provided by MOOCs should be higher

because of very large number learners that access and complete a MOOC. Evidence shows that MOOC completion rates can be low if the quality, delivery and candidate perception of value are not high enough (Poyiadgi, 2014). One of the reasons for dropping student enrolment in engineering MOOCs is the unavailability of transfer of credits completed to other universities e.g. towards completion of a formal degree or diploma. This issue is especially important for engineering students because any un-accredited credit worth very little to be used for any employment-related benefits.

A parallel can be drawn here with the market of IT certifications. IT vendors, such as Microsoft and IBM, promoted the credibility and take-up of competency in their specialized software. Today, these certifications have evolved into certification pathways. These certification pathways not only validate competency on a particular software/ platform but also provide a hiring standard for employers. MOOCs started from a similar position in the 1990s. Today, MOOC providers should capitalize on the potential of MOOC assessments, probably not to help gain a job but certainly to help gain an interview.

In 2013, The American Council on Education (ACE) assessed five courses from MOOC provider Coursera (Tony Bates, 2013). These courses for review were selected by Coursera in consultation with their partner universities. These courses were already offered on campus or were using content similar to an on-campus course. Based on ACE's review criteria, all five courses were recommended by ACE for academic credit. Despite ACE recommendation, each college/university was free to review these credit recommendations and determine how they may align with their general education requirements or degree programs. There was no guarantee that any university or college will accept the ACE credit recommendations. One important point to note here was that these were courses developed by faculty and already reviewed for credit in their university system in some cases. The only difference was that these courses were now offered through Coursera as MOOCs. The ACE review process is a course content focused review. It doesn't address effectiveness of the pedagogy in terms of learning outcomes. This evaluation of courses by ACE was strongly criticized for its inability to address the main criticisms of MOOCs: that they employ unsuitable pedagogy for online delivery, and that the student assessment process is fundamentally flawed. ACE accreditation failed to provide assurance that learners might be able to complete these courses and transferability of the credits earned through these courses to the regular university programs.

Maximization of the use and sharing of a MOOC credential is one way the credibility and monetization of MOOC can be increased. MOOC providers can ensure that learners take the test of the course in a secure manner. Once the learner has passed the test the next question is how the word can be spread to employers and how employers would verify the validity of a credential. Solutions to this credibility issue are available. One such solution is Mozilla's Open Badges standard. The Mozilla's Open Badges standard is a portable, secure, and digital representation of an achievement. Mozilla's Open Badges standard is expected to provide employers a common currency to determine skills of MOOC graduates. While

There also exists a group that argues accreditation would hurt the business model of MOOC. The group argues that accreditation should be left to the employers who hire MOOCs graduates (Joshua Gans, 2012). According to them, the inherently data-rich nature of online education is the reason why educational productivity increases with online education. Every minute detail (such as videos watched or links clicked) can be collected and analyzed in online education. In online education, randomized controlled trials can be conducted in a cost-effective manner. For example, we can randomly assign one of two videos to a large number of students and then monitor their performance on exams or other material. In

online education, we can learn about what works much more quickly. Still, MOOCs will suffer if they are not accredited. The fundamental problem lies in the normal behavior of students in being efficient learners. Given two choices of courses that lead to the same degree, the student will rationally choose the course that minimizes the effort. MOOCs will compete against traditional university-based courses and MOOC market may become "lemon market" if MOOCs are not done properly. The university's reputation will be tied to the MOOCs that the university offers. This is way the accreditation of MOOCs is very important. The path forward for MOOCs is that tests should be conducted on those MOOCs only that fulfill all characteristics of accredited institutions. That means Universities could provide the tests themselves. These tests should be offered under the conditions valid in that country and supervised by University staff.

According to Walter Russel (2014), an interesting solution for MOOC accreditation is a new, private-sector accreditation body called Modern States. The Modern Sates would be similar to the organizations that currently provides accreditation to colleges/universities, certify individual courses and create tests to assess learning of MOOC participants. The certifications provided by Modern States would be similar to current college/university credits. However, these certifications would be based on the content a student has learned. These credits would be transferable to traditional schools. That would help integrate MOOCs into the current engineering higher education system while retaining their flexibility and easy access. The Modern States would be able to accredit specific courses and not just the degrees as a whole. For example, Modern States could recognize the high quality of a freshman physics MOOC from MITx and then develop a test to assess student learning after completion of course, similar to a GMAT exam. Students who complete the MOOC and pass the test would earn accredited course hours from this new accreditation body. There exist enough such courses (such as poetry from Harvard University and Theology from Notre Dame University) that could lead to a full degree accredited by Modern States. Modern States would also develop tests and approve courses in other areas such as vocational education, career training, and community colleges in order serve a large population of students. By creating Modern States, a whole new field of academic innovation would flourish and provide blends of online and offline learning and new models of governmental financial aid. For example, core courses can be provided tuition-free to the students through a MOOC taught by a nationally renowned professor. The students can then attend supplementary weekly study groups with a professor in a Face-to-Face classroom setting. All of this could be provided at a lower overall cost than a traditional course today. However, this promising idea is faced by numerous challenges. A low-cost model of academic credits could be very disturbing for colleges/universities and their accreditation bodies that currently enjoy near-total control over academic credits. These colleges/universities and their accreditation bodies will resist against this idea. Still, this model is a serious effort at tackling with one of the most serious problem facing MOOCs. As such this model deserves serious attention. Open Educational Resources University (OERu) is a MOOC rival. OERu recently announced that students who complete an OERu course can have their course assessed for academic credit after paying a fee. These assessed credits would than would then be recognized by all the universities participating in the OERu (Parr, 2013). Theoretically, students should be able to approach any university with the credits they have accumulated and apply for a degree. Institutions need to assess these credits and if satisfied with the demonstrated learning of the applicant according to learning outcomes associated with the degree programs, applicants become eligible for graduation.

MOOCs and the Faculty

Is engineering faculty ready to use MOOCs? There exist two viewpoints. According to first viewpoint, MOOCs are truly a disruptive technology and they will fundamentally change what faculty do and how we do it. According to second viewpoint, MOOCs are a fad and there is no way that a MOOC can be as effective as a well-taught Face-to-Face class. After the hype settles out, things will go back to normal.

Engineering faculty needs to understand that technology can be used to convey knowledge and basic understanding of a subject in a better and cheap way. Therefore, faculty needs to move beyond simply providing information to students. If they fail to do so, there is a high probability they will be replaced by technology in the near future in a landscape shift of focus of the entire engineering higher education on competency and lifelong learning. As Kyle Peck (2013) pointed out "we need to move up the hierarchy of educational outcomes, to "re-place" teachers, accepting the more difficult aspects of education and leaving the less-demanding jobs to technologies and peers" adding that "the word "re-place" means higher education will still be here, but faculty's "place" — their role in the education of people — will change" (p.2). The emergence of MOOCs has provided a significant shift in the thinking of parents and students as well. This shift is a serious challenge for traditional institutions. As Clay Shirky (20103) pointed out "Things that can't last don't. This is why MOOCs matter. Not because distance learning is some big new thing or because online lectures are a solution to all our problems, but because they've come along at a time when students and parents are willing to ask themselves, 'Isn't there some other way to do this?" (p.2).

In the years to come, it is expected that the primary focus of higher education in engineering will be on developing higher-order skills and the in-depth understanding of complex subjects. The faculty at engineering institutions of higher education needs to change their focus as well. They need to move beyond disseminating, coaching, assessing and certifying and focus on activities that require their expertise. Faculty needs to understand that it is unlikely future students will engage with universities for multi-year commitments that separate them from family, work and other responsibilities and opportunities. Faculty needs to collaborate with others to define the skills and attributes required for people aspiring for different careers and futures. These defined skills and attributes should help people develop themselves and certify their competency. A one-size-fits-all education is a thing of past. Faculty needs to focus their attention on providing a learning experience that fit with the evolving lives of the leaners.

In the next 10 years, it is expected that more and more learners will come to colleges and universities provided they replace themselves successfully. These learners will engage with universities for shorter periods of time and increasingly use technologies (such as Skype, Adobe Connect and Google Hangouts) to join the courses. An increasing number of students will consider college education as they know they will be able to complete their degree at their own in a cost-effective manner. Faculty will increasingly focus on the development of skills, high-quality assessment, and comprehensive feedback. Universities will certify sets of credentials that are much smaller than the degrees. Universities will allow learners to accumulate these credentials to document their eligibility of the degree and readiness for the roles they seek. The result of this painful transformation would be a low-cost, efficient, and more accessible system that is focused on more important outcomes.

According to Kyle Peck (2013), "Any teacher who can be replaced by technology deserves to be." (p. 1). Faculty is not just to provide information but to provide the pathway through which learners could find the information. Educators and administrators of educational institutions should

not consider them 'in competition' with technology. This way they could be in a better position to integrate technology into their courses and increase effectiveness of their teaching. Faculty can offer a lot that mechanized systems cannot but has little time for such offering. Faculty need to look for opportunities that technologies provide to build relationships, motivation, and relevance in their teaching.

However, such required transformation of the faculty is faced with numerous challenges. One such challenge is institutions strategy to reduce the teaching faculty to cut costs. Many institutions have even become reluctant to hire new faculty and retain current ones. Institutions are reducing the number of tenure-track positions available and emphasizing on use of short-term contractual faculty. In 2012, The University of Florida announced that it was dropping its computer science department in a bid to save about $1.4 million. The school was planning to eliminate all funding for teaching assistants in computer science, cutting the graduate and research programs entirely, and move the torn remnants into other departments (Steven, 2012). Institutions claim that technology can replace a faculty at a cheaper cost. However, doing so deprive students of the value of a true education. While today's students are more comfortable in finding information from many sources such as Internet they still need assistance/support to understand what they find. Just like pharmaceuticals cannot replace doctors, mediated learning resources cannot replace educators. Technology cannot replace educators but can improve their performance. Cutting back on number of faculty is not a solution and administrators should equip faculty with tools that enable them to focus on the most important aspects of learning to go farther and faster.

The perception of faculty about online education may also be a barrier to this required faculty transformation in the era of online learning. For the past nine years, one-third of the academic heads of US institutions of higher education thought that their faculty accepted the value and legitimacy of online education. The number of programs and courses online are growing. However, the perception of the academic heads of the acceptance of this learning modality by faculty decreased in the most recent year with only 30.2 percent of heads believed their faculty accepted the value and legitimacy of online education (I. Elaine Allen & Je! Seaman, 2013). Academic heads at institutions with fully online programs had the most positive view of their faculty acceptance however the proportion agreeing was still 38.4 percent (I. Elaine Allen & Je! Seaman, 2013).

With soaring popularity of online courses, a new debate has started about their ownership. While this debate is little noticed, it can have huge impact on longstanding traditions of faculty control of courses they create, and influence the future and success of online higher education in engineering. For universities, MOOCs offer an opportunity to make significant amount of money by registering virtually unlimited number of paying students in a MOOC. However, faculty fear their work may be altered for the worse, or that universities will employ other, less-qualified people to teach them. It is quite understandable given that developing engineering courses require much significant efforts from faculty and extensive resources. In a survey of US Universities, it was found that only 10 percent institutions let faculty keep sole ownership. More than a third of universities claimed complete control over courses and materials for themselves (Sarah Butrymowicz, 2014). The faculty union at the University of California at Santa Cruz had been fighting with University administration over intellectual property rights. The faculty at University of California at Santa Cruz was told that anyone who created an online course for Coursera would have to sign a waiver giving up ownership. Union pointed out that, under California law, individual professors and not their universities own the rights to the course materi-

als they create. While Coursera agreed to retool its course development agreement in response to "legal concerns" it was still unclear what would those change entail.

MOOCs and the Students

Are students ready to accept MOOCs in engineering education? Do MOOCs fulfill their learning expectations? A study of students' involvement in MOOCs by Bailey, Cassidy, & Breakwell, (2014) provides some interesting findings. The students participating in the study were form US, UK, and Ireland. The participating students belonged to a verity of study disciplines including engineering.

An examination of the relationship between workload and student engagement suggested that the student group with the lightest workload had the highest overall level of participation. A comparison of activity across all groups and all tasks levels groups suggested that the group with fewer assigned tasks showed a higher level of activity. Most of the tasks were optional. However, the existence of tasks appeared to create a sense of obligation on the participants, which left them feeling time-pressured. In a follow up feedback from students who didn't participate in the activities, 72% of non-participating students cited insufficient time as the reason for non-participation.

An examination of relationship between task design and engagement, showed that elements of gamification involved in the task may be factor in sustaining student participation. Establishing the relationship between level and nature of facilitation, the study found that having a subject expert as a facilitator may have a positive impact on student engagement. This was in contrast with the earlier studies (Edinburgh, 2013) which found that academic facilitation did not impact on student participation. This appears to be an area where MOOCs diverge from online learning more generally. According to Arbaugh (2010), "active facilitation is a key component of successful online courses, requiring instructors to 'review and comment upon student comments, raise questions and make observations to move discussions in a desired direction" (p.1236). It is possible that large scale of MOOCs and the diverse learning experiences that learners bring to MOOCS make it a challenge to provide a level of online facilitation that is capable of enhancing the student experience.

MOOCs also allow students to join courses at any time may be few weeks after the course begins. The study of Bailey, Cassidy, & Breakwell, (2014) found that group of students, in which students joined late, were less engaged in various course activities. It is interesting to note that the course remained open for 6 weeks after all the content had been delivered to allow late joiners time to complete. This implies that probably students were out of sync with the course schedule and wider community and so were less likely to engage. It may also imply that students joining late are less likely to go through the course induction process and thus may have been less prepared for the course.

IMPLICATIONS AND RECOMMENDATIONS

Tests, whether single or a combination of formative and/or summative tests, are the only real way to successfully measure the learner outcomes from MOOCs. This credibility is more important for engineering MOOCs because engineering graduates professional work can produce significant impact on the safety and well being of human lives. It is very important that the tests of their learning be as rigorous as possible. Various regulatory bodies place stringent requirements for testing engineers for their learning and knowledge. Informal testing may be suitable for few low-stakes courses. However, real credibility of MOOCs will come from both what and how you test along with the outcomes for learners. Candidate impersonation and exam cheating are the biggest threats to credibility and value of any course. For high-stake MOOCs

we need proctors – whether in-person or remotely – to ensure there is no candidate impersonation and opportunities to cheat are minimized. In their current form, Internet-based tests cannot provide the level of security required to enhance creditability of MOOCS assessments to a level in the consciousness of their stakeholders. The MOOC experience also needs to be seamless for learners and institutions. MOOC providers need to ensure that their MOOCs offer a meaningful, radical alternative to conventional higher education, and focus on their value as educational broadcasting, notwithstanding their important value in forcing many elite institutions to take much more seriously for the first time the potential role of credit-based online learning.

Clayton Christensen, in one of his books, "Disrupting Class" (Christensen, Horn, & Johnson, 2008) discussed the possible future of education. It is a future in which the role of faculty is changing from "Sage on Stage" to "Guide on the Side." Looking at initiatives, such as Khan Academy, we can start realizing this future where faculty is doing exactly what was depicted by Christensen. We see flipped classrooms where students watch the video lectures at home, perform virtual lab experiments, and faculty facilitates the learning in a more interactive way in the classroom. Students progress at their own pace and faculty monitors individual progress. Faculty facilitates student centric learning, overcome any obstacles, and provide guidance as needed. Every new idea is faced with resistance by incumbent within the existing profession. MOOCs are no exception. However, the change is inevitable. Once faculty recognizes MOOCs as a useful tool and become adept at using it to meet their needs and styles MOOCs will become an effective resource.

A different thinking is required on part of MOOC providers with respect to group formation in engineering MOOCs when learners have very weak social ties and their commitment levels during course vary significantly. A rapid group formation approach can help ensure some level of social learning throughout the course. Strengthening social ties is important and can help improve socialization process in a learning environment with a large number of learners. Strong ties can help build strong connections and learners will be more likely to stay with the course and the group.

FUTURE RESEARCH AREAS

Besides instructional design aspects of MOOCs, further research is needed to analyze the learners' personal circumstances in their ultimate success. In one case, it was observed that although unemployed people represented only 5% of those who registered for the MOOC, they represented 23% of completions. This contrasts with those in full-time employment, who represented 46% of the MOOC population but only 13% of completions (Bailey, Cassidy, & Breakwell, 2014). These statistics reinforces the importance of the availability of time as a factor in engagement and an area that needs to be investigated further.

It has been observed that a significant majority of those who completed possessed a post-graduate qualification. This suggests that perhaps the MOOC format is best suited to self-directed learners. This is important to consider at a time when MOOCs are sometimes touted as a panacea for a range of educational ills. Indeed, it underscores the need to consider the intended audience when planning a MOOC. Further research is needed to analyze whether it would it be useful to implement more formal stratification in MOOCs to better cater for the mixed abilities and diverse backgrounds of participants. Another area that needs to be further investigated is the kind of strategies will students need to have in place to manage workload and the potential information overload generated by the large number of discussions and sources of data provided by a MOOC. Another important area is the learning styles of learners. Future research is

needed to analyze whether student must learn how to learn when they participate in a MOOC. A deep insight into this issue can help MOOC provider significantly enhance the MOOC experience.

Faculty involved in MOOCs are always looking to learn and/or fine tune their instructional design skills for MOOCs. The faculty often involves in collaborative efforts in designing MOOCs. Another interesting area that would need further research is to how the collaborative group learning opportunities before, during and after the MOOC can be structured and encouraged.

We all measure quality from a different framework of understanding. The real quality of MOOC, the impact of students learning on his culture, is not measured in dollars, or votes or students. Future research is needed as to how engineering MOOC providers and participants are going to support the quality they believe in.

CONCLUSION

Evidently, a number of factors are impacting education. First, universities are aggressively working to expand their online offerings and adopt effective technology-enabled learning. Second, an increasing number of students, with diverse backgrounds, willing to get higher education. Third, there is a need to shift focus from simple knowledge recall to development of skills to find and use information effectively. In this context, it is important that 21st century learners are provided with digital literacy skills to equip them for an increasingly complex and changing societal context (Jenkins 2009). Finally, the proliferation of new competitors has called for a new strategy for traditional institutions to tackle new competitive niches and business models. MOOCs represent an example of how technologies can disrupt the status quo of education. MOOCs are a forewarning of further changes in education to come. There is a great hype about what MOOCs can do. Whether or not MOOCs will fulfill the promises of this hype is a mote point. But one point is clear: we need to take MOOCs seriously. More importantly, both MOOCs providers and traditional institutions, need to make more informed design decisions that are pedagogically effective and lead to enhanced quality learning experience for all learners.

Careful tuning of teaching-learning process is a must for any large scale adoption of technology for engineering education. We need to address issues such as examinations, evaluation, and certification. All stakeholder, such as students, teachers, institutions, and employers, must be taken into consideration while examining the value proposition offered by technology-based education. The transition of higher education towards greater use of technology, may take several years. Technology-based learning will continue to mature and evolve with an increase in number of learners. However, this also represents a great challenge with respect to enhancing the quality of learning. In developing countries, such as India, we see a very large number of MOOC learners. Enhancing quality of education on such a large scale would be possible only with extensive and appropriate use of technology, adopted with ingenuity and focus.

This chapter has analyzed the present MOOCs in this context. More specifically, the chapter provided, explored, examined, and provided suggestions for various pedagogical and technical issues in an effort to establish some best practices for enhancing MOOCS in engineering education. It is hoped that a successful implementation of the suggestions provided will lead to their adoption in MOOCs for other spheres of higher education.

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KEY TERMS AND DEFINITIONS

Accreditation: A process in which certification of competency, authority, or credibility is presented.

cMOOC: In a cMOOC, learners are encouraged to contribute actively, using digital platforms and technologies.

Connectivism: A hypothesis of learning which emphasizes the role of social and cultural context.

Engineering: The application of scientific, economic, social, and practical knowledge in order to invent, design, build, maintain, research, and improve structures, machines, devices, systems, materials and processes.

Knowledge Management: The process of capturing, developing, sharing, and effectively using organizational knowledge.

Massive Open Online Courses (MOOC): A course of study made available over the Internet without charge to a very large number of people.

xMOOC: In an xMOOC, the MOOC is designed to be in addition to something else (for example a university course).

Chapter 11
MOOCs in Engineering Education:
First Practical Experiences from two MOOCs

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ABSTRACT

Massive Open Online Courses (MOOCs) are a phenomenon of these days. Therefore it seems just a consequent step to carry out research studies how MOOCs can be integrated best in our daily life. This work aims to describe first experiences from the implementation of two MOOCs on a new developed platform. Both courses are related to engineering education: one to physics and one to mechanics. First the concept as well as the development and then also the evaluation is pointed out. It can be concluded that there is potential for educational institutions, but also barriers which must be taken into account.

INTRODUCTION

Since the introduction of the World Wide Web the way we deal with learning and teaching content has changed arbitrarily. In the very first beginning back in the early 2000 so called Web Based Trainings and Learning Managements Systems (Helic et al, 2004) popped up with the idea to deliver educational content to the learners via a new distribution channel (Maurer, 1996). Students as well as teachers were able to download digital content and to communicate using different possibilities as discussion forums or chats. Some years later the term Web 2.0 described a new way how users deal with the WWW (O'Reilly, 2006). Weblogs, Wikis or even Social Networks allow us to interact with online content or other people directly. Stephen Downes (Downes, 2005) introduced E-Learning 2.0, describing the use of Web 2.0 tools for teaching and learning (Ebner, 2007). Since then the use of Weblogs (Farmer & Bartlett-Bragg, 2005), Wikis (Augar et al, 2004),

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Podcasts (Towned, 2005) and Social Media (Ebner, 2013) in education became quite popular. Nowadays also the increase of mobile devices and fast (mobile) Internet access allows working with learning content nearly anytime and anywhere (Ally, 2007). Finally the access to digital learning content is getting more and more easier based on so called Open Educational Resources (Schaffert, 2010) as defined by the UNESCO (UNESCO & COL, 2011) in 2002.

Bearing in mind all these steps it becomes obvious that the connection of learners interested in a specific learning content might be from special interest. Siemens (2005) called this the idea of connectivism: A group of learners learn through online discussions and by using their personal learning environments in manifold ways. It follows the idea on the one side that learning and teaching situations occur through the connection of people and that on the other side the distribution of learning content is done from different sources (e.g. Weblogs of students). Following consequently this approach Siemens and his colleagues started a first online course in 2008 on trends and possibilities of learning with the Internet (McAulley et al, 2010). Due to the fact that more than thousand students attended the course, it was called a Massive Open Online Course. "Massive" because of the high number of students and "Open" because of his open nature – anyone can attend and any learning content is free available and useable. Just a couple of years later very famous universities like Stanford, Harvard or MIT attracted thousands of learners all over the world with their MOOCs, too (Carson & Schmidt, 2012). But there is an important difference between Siemen's course and such of these universities. As mentioned above Siemens based his idea on the learning approach of connectivism by connecting people and their personal tools. In contrast the courses of the universities offer an own developed platform with courses on them for the public. Nowadays we call courses according to Siemen's idea cMOOCs ("connectivism") and the others xMOOCs ("extended").

Table 1 points out the main differences between these two possibilities. Of course in practice the borders are not so explicit – for example an xMOOC has not to follow exclusively the behaviorism learning theory, there are also examples for a constructivist learning approach (Kukharenko, 2013). It must be seen as a first rough classification.

When a closer look is done it becomes quite clear, that for a traditional university with more a less typical face-to-face lectures a so called xMOOC fits more to their today's role. An xMOOC can be simplified described as a free accessible lecture done online. Due to the fact that the first xMOOCs attracted more than 100.000 students the term MOOC became very popular and many universities jumped onto it. Today there is a debate if such MOOCs are able to change universities' roles or if they even revolutionize Higher Education.

Based on those developments the University of Graz and Graz University of Technology started a project on developing a MOOC-platform in September 2013. The focus is strongly related to offer xMOOCs because of the low budget (providing

Table 1. Difference between cMOOCs and xMOOCs

	cMOOC	**xMOOC**
Learning Theory	Connectivism	Behaviorism
Learning Content	Emerging, teacher offers topic and students bring in	Structured, brought in by a lecturer
Communication	Different possibilities (social media, video conferencing)	Discussion forum (often not moderated)
Learning Outcome	Completely open, highly self-regulated	Self-Assessment, based on curriculum
Role of Teacher	Coach, facilitator	Instructor

cMOOCs need much more effort from teachers and produce high personnel costs). Additionally it must be mentioned that providing an information system does not automatically lead to a perfect online course. Therefore further research studies were started in parallel to guide lecturers through their content development as well as their online lecturing. For example previous research (Khalil & Ebner, 2013a) pointed out the lack of interaction during such courses, which leads to dissatisfaction on the learners' side (Khalil & Ebner, 2013b).

In spring 2014 two different MOOCS with a special focus on engineering education have been done: One in the field of physics and one in the field of mechanics. Both MOOCs have been visited from interested learners all over the German speaking area. In this publication we would like to address to following research questions:

- How can a MOOC for engineering education look like?
- Which structure has that MOOC to follow?
- Who is attending such a MOOC and what are the experiences of the learner?

RESEARCH DESIGN

This research study follows strongly the description of a case study. A case study is traditionally associated with process evaluation (Yin, 2011) and explores a bounded unit (Hill & Millar, 2015) in order to Achieve a rich description of certain perspective (Torrance, 2005) as well as a single case (Stake, 1995). Therefore we describe our approach how we implemented it and describe first experiences from a provider's perspective as well as some first evaluation results from learners. The research study is descriptive but should help other MOOC providers to bring their content to broaden public. Of course our study is strongly related to engineering education, for other disciplines the approach might differ arbitrarily.

xMOOC: The Core Elements

Due to the fact that our case study is about two xMOOCs in the field of engineering education, cMOOCs will not be in the focus of our research study. As mentioned in the introduction there is an arbitrarily difference between these MOOC types.

According to the literature (Conole, 2013) (Wedekind, 2013) a typical xMOOC consists of the following core elements:

- Course structure with learning targets,
- Video lectures (lecture recordings or video productions),
- Additional learning content according to the video lectures
- Asynchronous communication possibilities (e.g. discussion forums)
- Self-assessments according to the video lectures
- Certificates for successful completion of the course
- Information system that provides all these contents

Mostly a xMOOC is offered over a longer period of time between 6 and 10 weeks (Shaples, 2012) and the learning content is didactically divided into smaller learning packages. The main content is offered by video using different form and styles (for example screencasts, interviews, …). Each single course provides a clear start and end date (Lipson, 2013).

There are lots of different challenges during and beforehand the implementation of xMOOCs depending on different stakeholders' perspectives as addressed by Kopp et al. (2014), but most often discussed is the low retention rate or vice versa the high drop our rate (Meyer, 2012) (Jordan, 2013) as well as the lack of interaction (Khalil & Ebner, 2013a). Both issues are directly related to the huge amount of participants and are not unknown in the field of mass teaching in today's face-to-face universities.

MOOC Platform

Before starting to think about the general concept of a MOOC, some technological aspects have to be addressed. First of all the question on which platform the content will be offered. In the case of xMOOCs there would be for example the possibility to use the huge platforms provided by MIT, Harvard or Standford, called Udacitiy, edX and Coursera. On the one hand offering courses there would maybe attract many learners worldwide. On the other hand our public foundation clearly stated to support only MOOCs in German which are not really supported by those platforms. Therefore it was decided to start our own platform, called *iMooX*. Following consequently the idea to bring *open* online courses to a public audience in the sense of Siemens (2005) this must be done also by ourselves (all other platforms restricted the access to course material after the end of the course for example). Furthermore we also proposed that the idea is not only to offer courses for academia, but also for a broader target group. Especially school children as well as elderly people were – and still are - predefined target groups. The project was initiated by the University of Graz and Graz University of Technology. Due to the fact that both are well-known representatives of Open Educational Resources (OER) in Austria, they see MOOCs just as a further step towards Open Education (McAuley et al, 2010). So from the very beginning of the project it was defined that each course offered by *iMooX* must be offered as OER using standard creative commons licenses. Which kind of license each course material follows can be defined by the teacher or the appropriate institution.

Concerning technical issues of the platform a so-called already existing Learning Management System (LMS) has been taken (Dietinger & Maurer, 1998) and rearranged. The rearrangement is on the one side a redesign due to the fact that a typical LMS uses a very old graphical interface and style concepts. Bearing in mind the new target group (children and eldery people) a redesign was also necessary to overcome usability issues. Nowadays a typical LMS provides a high number of different functionalities, which leads to users' frustration. Especially if dealing with children or no Internet power users, the interface must be as simple as possible. Finally the core elements of an xMOOC must be taken into account: There must be a course description, a course structure and course content (videos, files, self-assessments) as well as a possibility for discussions (forum). So from a technical perspective we needed an information system, which is attractive and simple and is able to serve a high number of users simultaneously.

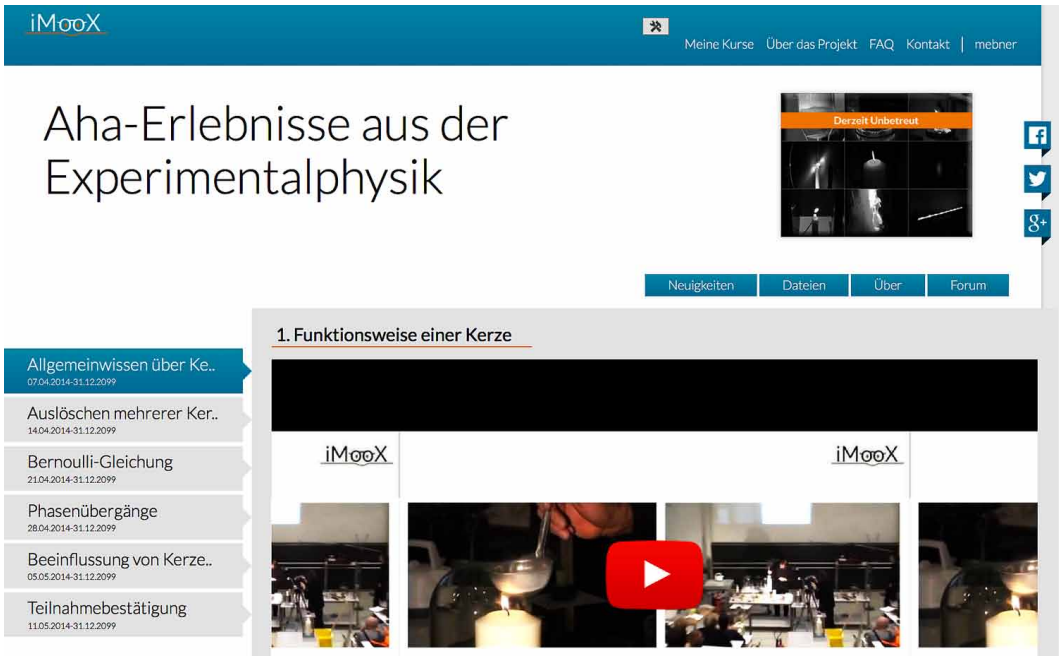
Figure 1 points out the final result. On the left side the course content structure with weekly opened tabs can be seen. In the main part the learning content (videos, files, self-assessment) is placed. The blue bar allows reading news related to the course, the course description as well as a download possibility for all offered documents. Finally the discussion forum can be entered or a post on social media can be done using the appropriate buttons. Each course has to follow exactly the same structure, which offers learners one familiar interface through the whole system.

iMooX can be summarized as a small-scale LMS with a simple course viewer and a user management. A learner can simply register on the web site providing a username and an email address. Afterwards he/she can choose a number of courses (offered via a course description) and just register for them.

MOOCs about Physics and Mechanics

First of all it must be distinguished between the concept phase ("How to make the MOOC?"), the development phase ("How can the MOOC be done?") and finally the lecturing phase ("How is the MOOC running?"). We will describe each phase in detail in the next chapters.

Figure 1. Course overview



Concept Phase

The concept phase is maybe the most important and also the most underestimated one. Only if there is a clear concept all other steps can follow smoothly. Therefore we developed a checklist which has been published in another research study (Lackner et al., 2014). The list followed the idea to bring "all elements together and into a structure to provide forthcoming MOOC experts, administrators, developers as well as teachers a comprehensive checklist and framework for their daily work with (Massive) Open Online Courses". The final list is quite long and not all points are absolutely necessary for each MOOC but on the other side it should cover all issues that might be considered.

The first category is about the core requirements, mainly about the platform itself, e.g. which one should be selected and so on. We can directly switch to category 2 as figured out in Table 2.

Very important for lecturing online with a MOOC is to provide small pieces of content divided into equal parts. For the physic MOOC this was quite simple due to the fact that the content was a series of experiments done in a huge lecture hall. For the mechanic MOOC we decided to follow the general lecture structure because the MOOC was primarily done to assist a group of learners doing a postmaster program at the university in a distance format. All other points of the category were discussed and considered.

Table 2. Category 2 of MOOC Checklist (Lackner et al, 2014)

2.	Structure
2.1	Divide the course into equal parts ("course units")
2.2	Think about a recognizable structure of the different units and design it
2.3	Divide the units into different environments (according to the objectives)
2.4	Organize the activities and assignments so that they are feasible ("time management")
2.5	Create a preliminary course unit ("socializing") before starting with content

As mentioned above the physic MOOC is a series of live experiments done in a huge lecture hall. Therefore each experiment was planned and exercised beforehand so that all operations are going hand in hand.

The mechanic MOOC follows a different concept. Due to the fact that a student of mechanical engineering has to get an intuitive understanding of structural behavior the education is strongly based on visualizations. Brohn (1983) expressed it in some few words: "The language of intuition is visual, just as the language of analysis is abstract and symbolic." Therefore it is from high importance to visualize the content in an appropriate way. It is from high importance that students understand how to begin a drawing or even a calculation. Not only the result is of interest but also the way to it. This leads to two major decisions about how content should be available:

1. Calculations and drawings must be comprehensible in the sense that also the way to the final result is visible.
2. Students must be animated to work with the content. So important content should be practiced even online.

This conceptual thoughts lead directly to the development phase.

Development Phase

Physic MOOC

In the concept phase it was pointed out that the physic MOOC should be a series of live experiments done in a huge lecture hall. The goal is to bring such experiments to a broad audience because even in schools it would not be possible to reproduce it. The experiments were done for a large number of students to increase the authenticity (live effect). With the help of three video cameras (one of them was a high-speed one) each experiment was filmed.

Because of a very careful planning phase a full professor assisted by a research assistant within three hours did more than 50 experiments. Afterwards the ten best experiments were chosen and one professional producer cut the final videos. Furthermore additional web resources and written explanation were carried out as well as a couple of questions for the weekly self-assessment.

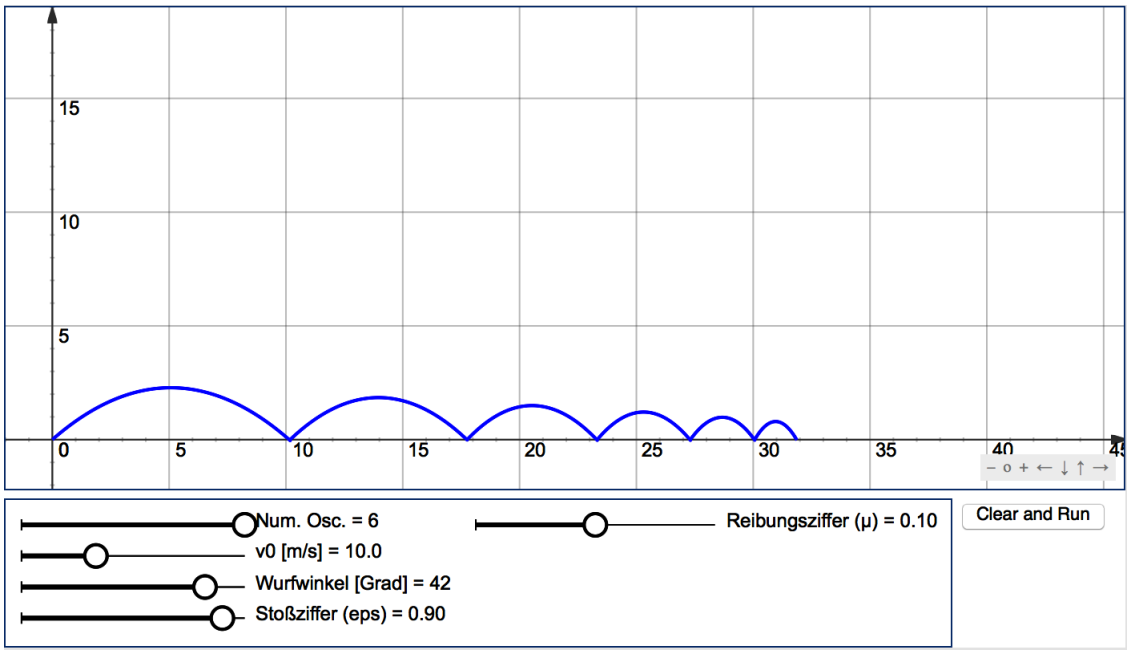
Mechanic MOOC

Based on the two major postulations – drawings and calculation must be comprehensible; students have to work with the content – it was decided to carry out two main components for this course:

1. The main content of the lecture was captured from the screen of the professor. He worked on a tablet PC using empty PowerPoint slides and wrote / drew directly on it. A screen capturing software (Camtasia) recorded all his activities on the computer screen and an external microphone recorded his voice. In summary six lessons (each 45 minutes) were recorded and finally cut by a professional producer.
2. Following the idea to enhance student's activities so called Interactive Learning Objects (ILO) were carried out. According to Guttormsen-Schär and Krueger (2000), interactive simulations can demonstrate the conditions of actions and events in the real world and support a constructivist learning approach within Technology Enhanced Learning (Holzinger, 2002a). Therefore a number of interactive objects programmed with java scripts were developed (Figure 2).

Finally additional web resources and written documents enhanced the videos and ILOs. For each week exercises were created. The right solutions were part of the weekly self-assessment.

Figure 2. Interactive Learning Object "Throw with multiple bounces"



Lecturing Phase

All course components were implemented to the platform, divided into weekly equal episodes. In March 2014 the mechanic MOOC was started and in the beginning of April also the physic one. Nearly 500 participants registered for the physic MOOC and also more than 350 for the mechanic course. This numbers are quite high, due to the fact that the language was German and both courses addressed more or less at least students or adult learners with high math knowledge.

EVALUATION RESULTS

General Outcomes

In this chapter we will point out some first results from our evaluation and observation. In the courses *Mechanics* and *Experimental Physics* each participant had to complete a questionnaire at the beginning as well as at the end of the course to evaluate the iMoox platform and the offered course. An evaluation form was placed right before the confirmation for participation in the respective course. In summary 116 learners filled it the first form out (63 for the physic course, 53 for the mechanic course) and 36 finished the course in time (32 for the physic course, 4 for the mechanic course). This means a completion rate of about 31% on average, which is quite high according to the data of Jordan (Jordan, 2013). Normally the rate is below 10%. Meyer (2012) reported that the dropout rates of MOOCs offered by Stanford, MIT and UC Berkley were 80-95%. For example, only 7% of 50.000 students who enrolled to the Coursera-UC-Berkeley course in Software Engineering completed the course.

The overall statistics point out that on average 68% of the participants are employed and that 54,5% of all learners hold at least a bachelor degree. 71% of the participants were male, only 29% female. Almost three quarter (73%) of all were located in Austria, only 6% in the German speaking part of Europe and 21% outside of them

(9% non German speaking Europe and 12% in the rest of the world). More than a half (51%) of the participants was older than 35 years old, almost a third was even older than 50 years (31%). This result shows, that these courses were mainly interesting for employed men, who were older than 35 years old and who had an academic degree.

Feedback According To the Platform

In the evaluation form we asked about the performance of the *iMooX* platform itself. Due to the fact that we are dealing with many different kinds of learners the web interface must be intuitive and easy to use. Figure 3 points out four answers according to the usage of the platform:

It can be stated that most of the users liked the platform (84%). Also the navigation as well as the structure of the platform meet users' expectations. Finally the user interface attracted about three-quarter of all users.

Outcome Concerning the Content

We also asked how the content of the courses attracted users and how the content supported them during their learning activities. Figure 4 displays the result in detail.

First of all on average 79% of all participants mentioned that they liked the course as such. The quizzes of the mechanic course got a higher score then the physic course. As mentioned above this may be due that the quizzes in mechanics are directly related to additional exercises instead of just repetitions of watchable content. The discussion forum as well as the tutoring of the course got the lowest numbers. This is not surprising, because only few messages appeared in both courses during the runtime and therefore only few responses of lecturers were necessary. Furthermore lecturers did not use the forum actively.

The content itself (videos and interactive learning objects) were rated very well as well as the course design and the structure. More than two-third of all learners were satisfied with the needed time for the course according to the proposed time in the course description.

DISCUSSION

In this section we would like to discuss the main outcomes and lessons learnt from two MOOCs with a strong focus on engineering education:

- **Course Structure / Course Content:** The course structure as well the course content was rated very high by the learners. For sure it can be recommended that screen capturing and interactive learning

Figure 3. General feedback about the MOOC platform

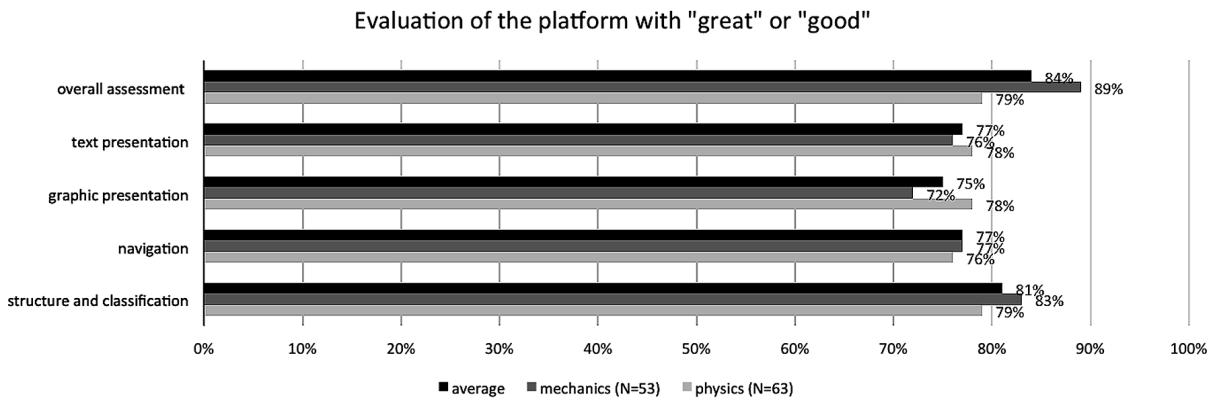
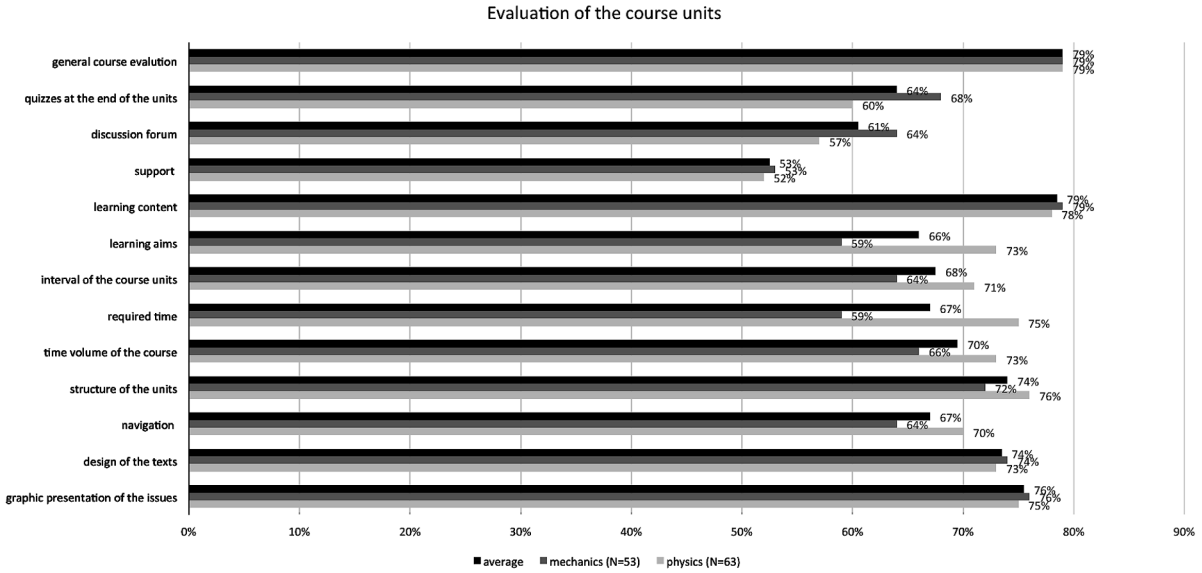


Figure 4. How do you like the provided learning content?



objects are appropriate methods to present content of typical engineering education. Especially if drawings and calculations are major parts of the course. Furthermore videos of interesting experiments with different camera views helped to visualize complex correlations.

- **Participants:** A very interesting outcome of the evaluation was that exactly half of the learners were older than 35 years. With other words the online courses attracted learners who are not students anymore, most of them older than 50. One student wrote in a personal email to the lecturer that he loves the online courses, because he is not able to attend any course in parallel to his job. Another one stated that he likes to get in touch with the university again and that he uses the course for his personal training directly related to his daily job.
- **Restrictions of The Evaluation:** One restriction of the evaluation is that we got only the feedback from those students who remained in the course. Due to the fact that we related the evaluation directly to the download of the course confirmation for participants, we just got this group of participants. So we did not know why others dropped out and did not finish the course. This will be a major issue for forthcoming research studies.
- **Costs and Broadness:** The course costs are high – our cost model (Fischer et al, 2014) summarized that we need for the production about 25.000 to 30.000€ for one online course. Of course the content is not a very dynamic one. This means that such a production can be offered for a longer time period. On the other side the audience is restricted to learners in a very specific area. Especially the mechanic course is a very specialized one. Together with the German language the target group can be small. This must be considered when starting such a course.
- **Personnel Expenditure:** It is hard to quantify how many people were and are involved around the MOOC initiative. In general it

can be stated that for each MOOC a team of e-Learning experts (didactical experts, developers), higher education developers as well as content experts together with the teachers planned, developed and run the MOOC. For each MOOC the effort of each person depends on different parameters. For example if the teacher was experienced in online moderation, there was no need for further trainings. As displayed in Table 2 there are many different parameters, which must be studied in depth in future research work.

- **Teachers Role:** The teacher's role in a MOOC differs of course from a face-to-face lecture. He/she is much more facilitator of a predefined content and has to keep always an eye on ongoing discussion in the forum. He/she should be experienced in online moderation, especially how students can be motivated to discuss their problems and exchange their thoughts online. Our case studies clearly pointed out that the main barrier for beginning to post in the forum is that it is not easy to describe engineering problems with text. Therefore links to uploaded pictures and formulas on other platforms appeared quite often. One teacher also mentioned that he looked at lease one time / day in the forum to keep him up-to-date.
- **Difficult Course Content:** Especially the mechanic online course is a very tough one. With other words the content itself needs high pre-knowledge in math and physics as well as beginners knowledge in mechanics. Therefore the course is only appropriate for a small group of learners. Within a very restrictive time frame, the number of possible learners is low. On the other hand we understand the course not as a typical lecture, but much more as a valuable resource for learning at any time, any place. Due to the fact that mechanics is one of the most difficult lecture content of studies like mechanical engineering or civil engineering such a course can be seen as a modern multimedia based learning content.

Limitations of the Study

The outcomes of our study are directly related to xMOOCs with a strong focus on engineering education. Due to the fact that engineering content is driven by visualization and math also other technical studies can benefit from the results. Finally the idea of our xMOOCs follows more or less the behaviorism learning theory. Online courses, which are using different theories, might be implemented in another way.

CONCLUSION AND FUTURE WORK

In this research study we carried out two online massive open online courses, one about physics and one about mechanics. We described the development of a platform, which serves as the provider of the content and how such MOOCs can be provided. Our first practical experiences pointed out that there is a huge potential to assist learners in a manifold way, but also that there are different barriers. Bearing in mind the outcomes it seems to be very important to open such kind of learning resources to the public because this strongly supports the lifelong learning process. In a long run this might be crucial, particularly when society's knowledge becomes an essential factor for tomorrow's economy. At the latest the future university will not only educate young people, but also adults and elderly people.

Our future work will address different directions – on the one side the platform itself should be adapted to further needs and offer place for another courses. Furthermore different parameters during the MOOC development should be researched in more detail. For example we have already carried out a study about business models for MOOCs

(Fischer et al, 2014). Finally also the learner itself as well as learning with MOOCs should be part of the research work to understand how such online courses will help us best and for which purposes. This case study was just the beginning of it.

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KEY TERMS AND DEFINITIONS

cMOOC: Massive Open Online Course using the theory of connectivism.

iMooX: A MOOC-platform with a special focus to the area of Austria.

Interactive Learning Object: A small application designed for learning a specific topic.

MOOC Platform: An Information system for xMOOCs.

MOOC: A Massive Open Online Course.

OER: Open Educational Resources.

xMOOC: Extended Massive Open Online Course.

Chapter 12
Teaching and Learning Requirements Engineering Based on Mobile Devices and Cloud: A Case Study

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ABSTRACT

Organizations have suffered a large (r)evolution at social, economic and technological levels. The increasing number of mobile devices on day-to-day of the general population and particularly among youth people, leads to the emergence of new paradigms in several areas of activity, particularly in education. As an example of a new paradigm in teaching and learning process, mobile learning supported by cloud environments and Bloom's taxonomy could be appointed. In this paper and in the context of a course of 1st cycle, following the guidelines of courses in Information Systems provided by ACM / AIS, it is proposed the use of Google tools, aligned with Bloom's taxonomy, the model Blended Mobile Learning-Context Oriented in a Requirements Engineering course.

INTRODUCTION

Higher education in general and higher education institutions (HEIs) in particular has undergone a great change for the different approaches used in the teaching-learning process (TLP) toward using the new devices and infrastructure.

According to a report by Ambient Insight Research, the U.S. market for mobile devices reached $958.7 million in 2010 and there is a projection for 2015 of 1.82 billion dollars. The ubiquity of heterogeneous mobile devices is hard to ignore. However, to take advantage of this trend is necessary to think beyond the formal, and start thinking

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about the performance of the support, i.e., today's devices mobile capabilities were unimaginable a few years ago, namely, persistent storage, displays, main memory and communications, among others (Quinn, 2011).

Currently, there is no consensus on the cloud computing definition; however, the definition produced by NIST is the most suitable (NIST, 2012). A key feature of this paradigm is scalability on demand, where the user pays for the amount of services that are really used (Armburst et al., 2010). Thus, the problems of space and sharing of documents has become a reality facilitated through the use of the cloud, particularly, with Software as a Service (SaaS) model.

In this context, the most emergent topics for research in these areas have their origin at the intersection of cloud computing, services and ubiquitous computing. Thus, four research areas were identified: 1) pluggable computing entities, 2) transparency of data access, 3) adaptive behavior of applications in the cloud, and 4) automatic discovery of application quality (Mei, Chang & Tse, 2008). In this research work, directly related to point 3) a proposal for a model and a case study that links education, mobile devices and cloud computing are presented.

The electronic learning environments could provide some facilities to learn complex concepts indirectly; students still encounter difficulties in coping with the complex concept of the requirements elicitation. More importantly, understanding the technical terms requires hands-on practice rather than mere theoretical learning. Learning via electronic environments, also called e-learning, utilizes electronic and telecommunications technologies for information delivery, especially for educational purposes. With the introduction of e-learning, most traditional learning limitations regarding learning times and places are now addressed in e-learning environments. Although e-learning technology offers different types of electronic learning environments such as web-based learning environments (WLE) and mobile-based learning environments (MLE), mobile-based learning has become an important modality used in e-learning environments, and more recently, the Blended Mobile Learning (BML) model (Khaddge, Lenham, & Zhou, 2009). Thus, it is necessary to, firstly, examine whether the solutions are according to the pedagogic aspects needed to be considered for teaching and, secondly, determine which type of content and how they should be available to students, i.e. to identify the learning context.

The TLP based on the model BML Context Oriented (BML-CO) (Moreira, et. al., 2010), on the one hand, leads to (1) the necessity from the existence of applications for mobile and fixed devices, and (2) the learning context, i.e., when? where? and why? a student intends to study with the support of a mobile device. On the other hand, leads to the selection / use of different software applications. Since the introduction of mobile devices in TLP, a large number of applications for different domains have been identified as previously mentioned. In most cases these applications are presented "in a flat fashion" that makes your selection / use particularly difficult. In this context, a web-based architecture was introduced from BML-CO model (Moreira et al., 2010) for the areas of programming, computer networks and information systems.

In the area of information systems, teaching and learning Requirement Engineering (RE) is a core subject for a three-year courses Bologna Process European Degree structure at HEI, in Portugal, following the Curriculum Guidelines for Undergraduate Degree in an Information Systems from ACM/AIS. Students usually learn RE as a chapter in an Information System course, in which it is expected that they, at the end of the course, are able to (1) Select and use techniques in requirements engineering process according to the problem to be solved; (2) Evaluate and use different techniques for prioritizing requirements

according to the problem to be solved; (3) Use a requirements management tool; and (4) Recognize technical developments in the area.

In this chapter it is proposed to use the Mobile Google Docs system (Google, 2013) i.e., a cloud environment in the BML-CO model to an Information Systems undergraduate degree, particularly in a RE course. With the proposed model, firstly, the teacher will have the necessary information to evaluate and revise the available tools in the area that teaches and, secondly, the students (working in groups) will have a complementary tool that allows them not only to acquire new knowledge but also to test their skills.

The model ensures that a student has the necessary conditions for accessing the course contents (texts, pictures / videos and audio) at a given time and with costs under control. The information related to the learning activities is stored for further treatment / evaluation. This information will allow knowing, on the one hand, the time, location and duration of activity and, on the other hand, the assessing knowledge of students.

METHODOLOGY

The main goal of this research is to propose a model to teaching learning RE based on Mobile Devices and Cloud. The proposed model is based on public domain tools (easy to use and accessible anywhere and anytime), it is free, allows students to daily use, inside and outside the HEIs and contributes positively in the TLP of elicitation and writing requirements. The study draws conclusions of student's perceptions on the topic, by providing suggestions about learning the subject via mobile devices.

Recognition of value and scientific validity of a research project are guaranteed by scientific methodology in which the work is based. The research methodology must be carefully chosen because it is based on philosophical assumptions that guide and aim to achieve the success of the research project. In order to achieve that success we chose the Design Science Research (DSR) methodology (Gregg, Kulkarni, & Vinzé, 2001; Hevner et al., 2004; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008) as a theoretical basis that supports the scientific validation of this study.

Firstly, it was do a reviewing the literature (Connelly, 2010), presented in the next section, i.e. Requirements Engineering, Cloud Computing and Education, Mobile Learning and the model that is the basis for the propose approach to teaching learning Requirements Engineering, in order two identify the literature gaps and the opportunity and need of a new approach to teaching and learning RE and, in this way recognize the change benefits.

The use of the DSR allows design and implements the proposed model, leading it in interaction with persons (students and teachers), technology (mobile devices) and organization (HEI), which needs to be managed if it is to consider a success application of the model (Hevner et al., 2004).

The DSR methodology is driven to the development of information technology artifacts intended to solve organizational problems known (Peffers et al., 2008), such as the difficulty in developing TLP RE. This has been most widely used in disciplines such as engineering and computer science, where the design is accepted as a valid research methodology and valuable, with several contributions from the scientific community to the extent of application of the methodology in the development of engineering artifacts (Archer, 1984; Eekels & Roozenburg, 1991; McPhee, 1997).

Additionally, this study employs a qualitative research (Denzin and Lincoln, 2009) method using structured interviews (Seidman, 2013) to the students. In order to, on one hand verify the familiarity between students with the use of mobile devices and application as well as to characterize the groups regarding their gender in a first stage, and on the other hand, to assess the added value of TLP, a particular topic to be taught based on the presented model.

The process of data-collection was based, as referred, on the use of structured interviews at the begin of the semester and after use proposed approach, the interview was structured in a set of questions presented in a systematic a highly precise way.

The data obtained from interview was re-worked and 'reduced' in order to represent major categories that describe problem in study. The data reduction facilitates the revealing of findings simply and efficiently.

RELATED WORK

Requirements Engineering

RE as defined in (Zakaria et al., 2011) is a branch, sub-area, of Software Engineering that studies the process of defining the requirements and it has been traditionally looked upon as the "front-end" of the software life cycle. Its main goal is to produce specifications from informal ideas for the problem that is to be solved. It is a new area started in 1993 when the 1st International Symposium on RE was organized. Requirements emerge in a highly collaborative and social process that involves stakeholders, project teams, management and product itself (Haron & Sahibuddin, 2010). The goal of RE is to understand the client needs and to provide a solution with the support of methods, techniques and tools. RE is an often underutilized discipline in software development (Panian, 2009).

Despite the added value that "*a good requirement will cause system success, but sometimes the system will fail because lack of controlling and monitoring on the system design*" (Zakaria et al., 2011), the related TLP with RE is complex, as can be observed from the survey presented and discussed in (Memon, Siti & Salim, 2010; Memon, Siti & Salim, 2014), that the current approach to teaching RE might have several limitations because an RE course requires skills development and therefore, more practical approaches should be employed to produce better results from the course.

A discussion of experiences concerning several ways of addressing the TLP in RE is presented by Memon, Siti & Salim (2010; 2014). These can be highlight the following: (Berenbach, 2005; Adroin, 2000; Regev, Gause & Wegmann, 2008; Regev, Gause & Wegmann, 2009; Gibson & Maynooth, 2000; Callele & Makaroff, 2006; Madhavji & Miller, 2005; Huijs, Sikkel & Wieringa, 2005; Rosca, 2000; Damian et al., 2005; Al-Ani & Yusop, 2004).

The deficiencies in RE curriculum have been reported by Berenbach (2005); also authors emphasize the importance of Requirements Engineering Education in Software Engineering and Computer Science programs and provide recommendations for its improvement.

A framework for teaching and learning in Software Engineering has been designed that incorporates repository of asynchronous, multi-media courseware that can facilitate new advances in research and technology and enable courses to be tailored to every individual student's needs and interests (Adroin, 2000).

Regev, Gause & Wegmann (2008; 2009) have used an experiential approach for teaching RE using a business game board that demonstrates the social/design problem complexities and richness of a development organization in the throes of creating a new product.

Gibson & Maynooth (2000) have examined the particular problems of teaching formal RE and used formal methods for teaching RE, and Armarego & Minor (2005) presented a study in which they compare the RE components of model curricula to the opinions of a sample group of practitioners and used their viewpoints and expectations to validate changes made to the learning of RE.

Callele & Makaroff (2006) reported an experience of teaching RE to a second year Computer Sci-

ence class to familiarize students with approaches to problem solving, development methodologies and development tools in order to broaden the student's view of software development. It was concluded that the less traumatic approach can produce better results than the current one.

It is suggested by Madhavji & Miller (, 2005) that the students should be involved in investigative studies or innovative questions as well as teaching the students prescribed sets of topics in an RE course. However, the drawback of investigation-based RE studies is that it will be more difficult for students to complete the course content together with investigation studies in one semester which can result in useless dataset for the students.

Huijs, Sikkel & Wieringa (2005) is shared an experience of teaching RE by integrating it in several courses and also challenging the students by authentic cases taken from business practices in which they had to apply theories and train their competencies.

It is reported by Rosca (2000) that RE course introduces students to the process, methods, and tools specific to this area, as well as the corresponding software quality issues. The course is offered in a lecture and lab format. To reinforce the concepts learned, students play different roles for eliciting requirements, collaboratively improving the quality of their standard requirements documents, or sharing their particular expertise with their teams when performing object-oriented analyses.

Finaly, Al-Ani & Yusop (2004) discuss the objectives and topics of RE subject. The lecturing methods used are role-playing and pre-assessment within a group environment. The aim was to create an environment in which students played a more active role in the learning process by transforming them from recipients of information to active participants.

As can be concluded from the various experiences presented in the ER TLP none has proved as the ideal, but always pointing to the degree of how difficult it is to teach RE.

Cloud Computing and Education

The cloud computing technologies have, a great potential to improve the teaching methods based on constructive and cooperative learning (Denton, 2012). Additionally, cloud computing is a familiar concept among college students, since they use several cloud services in their daily routine, such as Gmail, Docs, and Calendar from Google, iCloud from Apple, SkyDrive from Microsoft, and Dropbox from Dropbox.

As opposed to traditional web pages and applications, cloud computing offers SaaS to digital devices users, in order to apply these services openly and freely. Nowadays, there are several web applications that provide friendly user interfaces and powerful functions in the cloud. Therefore, many teachers and students are already using these cloud applications in their daily lives in the TLP context (Barnes, Gause & Way, 2008; Lin & Jou, 2012; Jou & Wang, 2013). Additionally, cloud computing offers a potential way to enable teachers and students to conduct formal lessons even without a standard indoor classroom since cloud services allow data share with anyone, anywhere, and at anytime (Astrid, Paul, Carol, & Jordana, 2012). These observations compelled several researches to suggest that these modern web applications could be a new way of engaging participants in meaningful teaching and learning activities (Alexander, 2006; Hughes, 2009; Schneckenberg, Ehlers, & Adelsberger, 2011; Thompson, 2007; Wang, Woo, Quek, Yang, & Liu, 2012).

The number of universities and educational institutions in the USA and UK that are adopting cloud computing has been constantly increasing over the past few years, leading to reduced costs and to the improvement of the efficiency and convenience of educational services (Berenbach, 2011). For example, the use of Google Docs (GDs) in the TLP in the State of New York, has reached three million students and 200,000 teachers (Cla-

burn, 2010). Another example, no less interesting, is presented by (Wood, 2011) that used the GD in a 1st cycle course where students have collaboratively written lab reports. Likewise, Bonham (Bonham, 2011) used the Google Spreadsheet and Google Forms (GF) so that students could collect data and produce graphics for a laboratory experiment. The University of California at Berkeley is operating its courses on a cloud supported by Amazon Web Services based on the SaaS service model (Berenbach, 2011). The University of Washington is adopting cloud computing to provide state-of-the-art productivity and collaboration tools to staff and students, supported by Microsoft (Windows Live including Email and Calendaring, Messenger, SkyDrive, Spaces, and Photos) and Google (Google Apps including Google Email, Calendar, Docs, Sites, and Talk) (Svahnberg & Gorschek, 2005). The University of Texas at Austin and the North Carolina State University achieved a substantial decrease in IT-related expenditures (Cisco, 2012). These universities only stand as examples of the ones that are leveraging cloud computing for economic reasons as well as for more advanced teaching, instruction, and data sharing.

Regarding the tools used in the respective courses their selection should consider a theoretical framework. Thus, the use of Bloom's Taxonomy (BT) (Krathwohl, 2002) appears as a suitable referential, since it is a metric tool that can provide the explanation for many issues that happen in the TLP. In this work, Bloom's Taxonomy is used to help to choose the techniques that potentially will fit the goal.

The educational objectives of BT (Krathwohl & Anderson, 2001; Krathwohl, 2002) are presented by a framework that retrieves what students are supposed to learn according to their educational profile. Krathwohl (2002) describes a variety of learning skills, starting with the lower order ones that form the basis of a hierarchy. This hierarchy, in turn, culminates in learning skills of higher order. The BT presented by Cheong, et al. (2012) specifies the following classification from the low level to high level: Remember, Understand, Apply, Analyze, Evaluate and Create, where each level has a set of verbs to be used in the definition of the learning objectives. As seen in Krathwohl & Anderson (2001), the very first step in cognitive process is "Remember". There are so many steps to learn at the first level of RE that it is not possible to continue before nailing them down. Although it is essential to go through the "Remember" level before "Understand", motivation may be taken into account. Therefore, explaining students the methods of teaching could be implemented in order to solve the latter problem.

As referred, the levels presented by Cheong, et al (2012) have different aims:

1. Retrieving relevant knowledge from long-term memory (Recognizing, and Recalling).
2. Determining the meaning of instructional messages, including oral, written, and graphic communication (Interpreting, Exemplifying, Classifying, Summarizing, Inferring, Comparing, and Explaining).
3. Carrying out or using a procedure in a given situation (Executing, and Implementing).
4. Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose (Differentiating, Organizing, and Attributing).
5. Making judgments based on criteria (Checking, and Critiquing).
6. Gathering elements together to form a novel and coherent whole or to make an original product (Generating, Planning, and Producing).

For a better understanding of the contribution of each of the steps of BT, regarding the TLP RE, the following is presented:

1. **Remember:** This is the beginning of the learning, as it is an essential part of the

study of new material especially when there is no familiarity with the concept like requirements.

2. **Understand:** This category includes "Interpreting, Exemplifying, Classifying, Summarizing, Inferring, Comparing, and Explaining". Worth to note that the interaction present in team work will facilitate implementing most of these sub categories. For example, when a student is teaching a teammate, the teaching position will force the student to apply all of the categories. Hence, teamwork is encouraged in RE class.
3. **Apply:** This category demands first to remember and understand the given material. The examples and assignments in lower levels are usually an imitation of what is covered in the class and follow step-by-step to repeat the procedure in the same context. However, in "Apply" cognition level, the student has to think deeper and modify the procedure, and make the known procedure to work in the new context. The assignments should be designed very carefully in order to accomplish the desired performance level.
4. **Analyze:** This category includes sub-categories as "Differentiating", "Organizing", and "Attributing". "Analyze" requires the ability to connect the constituent parts of the material. The ability to distinguish the different requirements types, functional, non-functional and business rules, with a critical eye will give the student the skills to differentiate and organize the different requirements types.
5. **Evaluate:** "Evaluate" is defined as 'judgment by standards' including critique and checking. In requirements elicitation, good examples are a result of (i) the comparison of several examples according to a purpose, (ii) the improvement of the elicitation, and (iii) the identification of deficiencies in the requirements.
6. **Create:** This category consists in the aggregation of each single element to form a whole. In RE, it includes producing the desired output by one's own way of solving a problem.

In this context, in addition to the referential used, it is necessary to analyze/select learning theories that best fit to the use of cloud computing technologies.

Denton (2012) suggests constructivism and cooperative learning. In the first case, Denton shows that constructivism suggests that students integrate previous knowledge to create new knowledge. This can be which is verified in cloud applications that contain tools that support activities to access previous knowledge, such as retrieving and sharing information. Furthermore, according to the same author, constructivism suggests that knowledge is created in a collaboratively way and the results of this construction are influenced by time and place. In the same way, the model presented in Moreira et al. (2010) shows that time and place have a direct influence on the type, number and duration of learning activities, i.e. there is a direct dependency with the learning context. Many characteristics of cloud-based applications emphasize these characteristics, such as synchronous write and publish on the Internet, among others.

The use of cloud computing technologies, including Google Docs, can lead to questioning why the information is not on the owner, i.e., why the information can be eliminated by the service provider at any time. However, it has been given the opportunity for students and teachers to record and save the changes over time, either in the cloud or on the device itself. Additionally, files can be saved and shared between lessons, an operation that goes against the theoretical referential, the constructivism.

In the second case, Denton suggests that cooperative learning is also another teaching approach that is aligned with the technologies of cloud

computing. The justification for this alignment is supported by all the possibilities that Google tools have to offer, including the possibility of sharing and publishing on the Internet.

The selection of the best tool(s) to implement the tasks that are necessary to answer to the several skills to be acquired by the student, according to BT, is always a difficult task, since it forces to study and experiment each one of them. However, Schrock (2012) proposes a classification of how Google applications can be aligned with BT.

Based on this classification (Schrock, 2012) it is possible to define a set of strategies for the integration of cloud technologies. Denton (2012) proposes several strategies that take into consideration the incorporation of characteristics of constructivism and cooperative learning within each strategy and the most appropriate tools:

1. **Group Projects:** Google Docs allows users to share and simultaneously edit documents, while keeping a digital record of team member contributions over time – Google Sites or Blogger;
2. **Peer Review:** There are a number of features available through Google Docs that are ideal for engaging students in peer assessment. For example, users can share files for viewing and editing, make comments, chat while working, and create specific forms to gather and share feedback. Users can publish forms online, or ask for people's participation through email notification – Google Docs, Google Talk, Google Forms;
3. **Presentations Built by Students:** Applying constructivism to the lecture concept, supported through cloud computing, provides an opportunity for instructors to involve students in the presentation of subject matter – Google Presentation;
4. **Simultaneous Discussions in Class:** Conducting whole class discussions is a common teaching. Stimulating students to address questions at the same time by sharing their thoughts through a cloud application – Google Presentation – is an exemplary approach;
5. **Collaborative Reflection:** For instance, a team of students can share a Google Document and type their reflections simultaneously, and the entire document can be published online or presented in class – Google Docs;
6. **Written Assisted:** Google Docs See revision history feature – Gmail, Google Talk;
7. **Class Inventory:** Google Forms is a convenient way for instructors to gather data to gauge student progress, classroom climate, or even both. A form can be published online as a standalone web page, or embedded into a LMS such as Moodle – Google Forms;
8. **Collaborative Construction of Rubrics:** For example, an instructor could use Google Forms to gather input on scoring criteria and then create a rubric from this information, with student help – Google Spreadsheets Google Forms;
9. **Website Publishing:** Blogger, Google Sites.

Mobile Learning

Mobile devices are small and portable. Thanks to wide applications of 3G/4G communications, they could be used for voice communication, enabling text anywhere at any time (Masters & Ngambi, 2007). Furthermore, its screen (Maniar et al., 2008) is up with inertia resolution and is able to show real time videos via broadband communication. As a matter of fact, some mobile devices can access and run a great variety of software including the ones owned by students who take them to classroom for learning (Tremblay, 2010).

In a traditional classroom, students need to physically turn up to listen lectures and engage in discussions; they need to occasionally check the white or black board, or projected slides.

They may also need to ask questions, write down notes or have discussion with their

classmates. Correspondingly, mobile Learning (mLearning) should encompass all these teaching components.

mLearning can be defined as a form of learning that makes use of mobile technology and gives students the ability to learn anywhere and at any time. This definition is based on the one given by Malley et al. (2003):

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.

In mobile communication, technologies are included mobile devices (laptops, tablets and smartphones) that have been undergoing a sharp evolution from the standpoint of capacity and reliability. In a more economic perspective, there has been a sharp reduction in prices. The HEIs have equipped their facilities with wifi networks, which contributed to promoting the use of such devices as well as the evolution of the teaching and learning processes.

In mLearning (Masters, 2005), the emerging new technologies such as Web 2.0 and cloud technologies (Google Drive, iCloud, among others) have been adapted for teaching and learning (Cochrane et al., 2011; Cochrane & Oldfield, 2011). Correspondingly, teaching is starting to move moving from the traditional way to this emerging area.

Our purpose in this project is to use multiple channels and Internet technologies in teaching and learning. For example, all information will be stored in a shared online system like Google Drive. This online mechanism is simulating the traditional classroom based teaching. In addition, mLearning is a free and open space for teachers and students to discuss their course related materials using mobile devices.

As opposed to other types of learning activities, the TLP with mobile devices began with the assumption that students are always on the move and have to deal with different contexts depending on their own activities. Perkins (Perkins, 1991) proves that the teaching-learning environments using mobile devices provide opportunities for innovation. Murray & Olcese (2011) shown that TLPs in which students have an active role, and "work" together with their teachers in a collaborative way, facilitates the construction of knowledge. In a survey made on students regarding the use of mobile devices in TLPs, it was concluded that mobile applications assist in the coordination of learning resources and students, and may also contribute to improving the educational activities that are part of this process (Educase, 2011).

Blended Mobile Learning-Context Oriented

All the proposals presented above demand the understanding of which path is to be followed in order to achieve the best TLP in RE. As can be seen in subsection Requirements Engineering several proposals were presented, but none of them took into account the use of new resources made by the cloud and mobile devices. However, in the work presented by Zowghi (2009) the author shared the experiences gained in teaching an online postgraduate RE subject. The playing role was used as a pedagogical tool to give students a greater appreciation of issues and problems associated with RE in quasi-real settings. In turn, Zowghi (2009) addressed some of the challenges encountered and the lessons learned with some suggestions on how to address, among other issues, the problem of distance between students and the instructor.

As the main objective of the this research is to adopt the Google Docs Mobile system (the cloud environment) in BML-CO model in an Information Systems undergraduate degree, more particularly in the RE course, a brief description of the BML-CO model is presented.

A TLP based on a BML model, in any field of knowledge, on one hand, leads to the (1) necessity of the existence of applications for mobile and fixed devices, and (2) the study of learning context, i.e., when? where? and why? a student requires the support of a mobile device. On the other hand, the introduction of mobile devices in TLP led to the identification/development of a large number of software applications for different domains. In most cases, this software is represented in a 'flat' fashion, thus hindering its use, especially when there are a large number of applications to consider in a particular area and/or scenario.

In this context a Web-based architecture was developed from a BML-CO model, for the programming (Moreira et al., 2010) and computer networks (Moreira & Ferreira, 2011), and information systems (Moreira & Ferreira, 2012) areas. The proposed model takes place on several platforms, offering tailored content to each platform, in the appropriate context and using only open source software.

This model ensures that students have the necessary conditions to access the contents (text, picture / video, audio) at a given time and with a controlled cost. The information is stored at the end of the learning activity. It will allow determining, on one hand, the moment, location and the activity time duration, and, on the other hand, assessing the student knowledge.

In order to provide a positive learning experience the LMS must be effectively integrated with other specialized systems typically found in an educational environment.

Proposal

The planning and design of this mLearning proposal is built based on (Yan & Kankanhalli, 2007, Smith, 2008; Li, 2009; Cochrane, 2011; Moreira & Ferreira, 2011; Moreira &Ferreira, 2012). The objective of this project is to deeply investigate the learning-based mobile devices and interactive environment, and improve the practice of teaching and contribute to better educational outcomes.

The study intends to add a tool to the model presented in section Related Work that allows supporting the TLP in a RE course. RE is a set of activities concerned with identifying and communicating the purpose of a software system, and the contexts in which it is used. Hence, RE acts as the bridge between the real-world needs of users, customers, and other constituencies affected by a software system (stakeholders), and the capabilities and opportunities afforded by software technologies (Kaur & Singh, 2010). Identify requirements in RE is an arduous task for a student in an initial phase of his graduation. We have identified Mobile Google Docs (MGD) (Google, 2011) as a good working model for this topic. The MGD is a free Web-based word processor, spreadsheet, presentation, hangouts and form editor whose data storage service is provided by Google. MGD works as a collaborative tool for editing documents so that they can be shared, opened, and edited by multiple users at the same time, and is, constructivist, cooperative and aligned with the learning theories.

System Design

One of the important and valued activities these days is the education anywhere, and at anytime. The HEIs is responding to these challenges by providing curricula's units (cu) that will satisfy the students with several profiles. Thus, teaching can and should be designed for those students who attend classes in person and also when they are in "transit". This educational activity includes all the work required in their planning, including scheduling classes, the type of room, the resources needed, etc. In situations where students are within HEIs and while they are in the classroom, they can use the PCs of HEIs or use their own mobile device (Bring Your Own Device concept, BYOD). When a student enters the classroom and wants to use a mobile device he/she just need to connect to

the wireless network and get authenticated within the system that validates if that student is enrolled at cu or not. The teacher asks the achievement of the task, giving indication to see the page in LMS concerning the planned activity for this session, as well as the Google tool to be used. For foreign students, the proposed approach is identical, since they should look for a hotspot where they can connect, or use a direct connection through the telecommunications operator.

The design of the system architecture for the TLP-based mobile devices will be built on the cloud tools provided by Google, and with an institutional LMS (Moodle). Regarding the design of the GUI system it was not necessary to consider this point, since used already take into account such characteristics. The interface between the tools of Google and LMS are provided by the LMS itself. The instructional design of this work is based on theories of learning (constructivism and cooperative), a theoretical framework (BT) and also taking into consideration the adaptability and scalability of the didactic material to be shown on mobile devices. The proposed synchronous communication for students and teachers to communicate with each other must be performed in order to reduce as much as possible the usage costs. Through the use of mobile devices it will be possible to carry out connections through Google Hangouts (GH) in order to save the costs of connecting to free Wi-Fi within the HEIs. The system is also designed so that the users (students and teachers) can conduct conferences / lectures based on a connection created through the use of students' numbers, which is associated with an account on Google that verifies the authenticity of users and check if he / she is registered in the LMS.

System Deployment

The system was designed to minimize the deployment process from scratch, i.e., the use of a web-based system and, in particular exploit the potential of the cloud. This way it will be possible to demonstrate the advantages of an environment of teaching and learning to mobile devices. The system is designed for the educational community of the institution, who have any type of mobile device, with only the requirement of having internet connection, web browsing capability and the ability to use the GH. Therefore, the access to the system is possible to take place anywhere at any time, which makes it able to provide a good learning experience through lectures in real time.

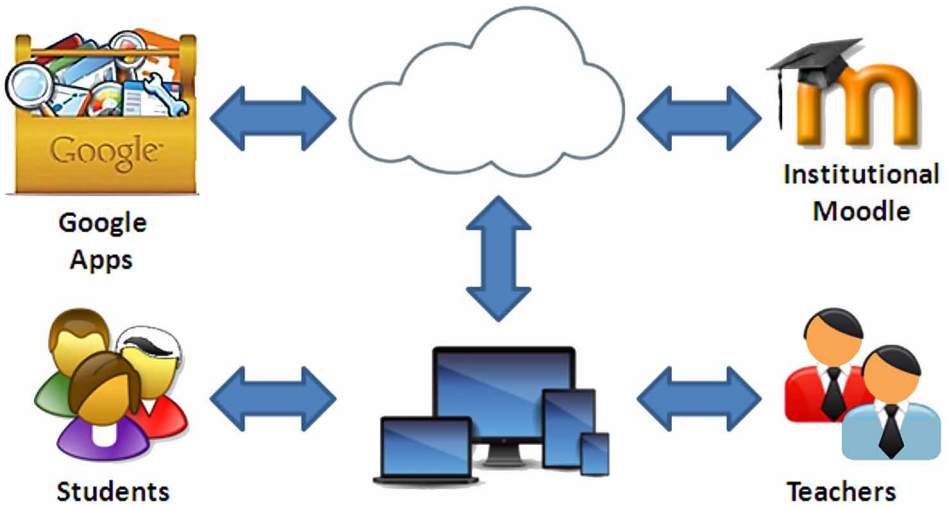
In Figure 1 is presents the proposed architecture model divided into two parts, an internal web server in the HEI with the LMS to manage all school activities, and applications of Google (GD, GF and GH). Students only need to use a browser.

All students at the beginning of the semester are enrolled in several LMS courses so that all communications (content distribution, using forums, paper submission, sending alerts, etc.) between themselves and the teacher are achieved by transparent and predictable manner (guarantee given by the infrastructure of HEIs), with the ultimate goal of getting everything registered.

Each teacher in their cu has the freedom to use all available resources in the LMS. In the case of RE cu some tasks were defined and some resources where used, allowing a learning experience through the mLearning.

In the first phase of the learning activity, the GD is used to identify the requirements (functional and non-functional) and business rules by labeling, while in the second phase, the GF is used for writing the requirements and business rules for further evaluation. Between the various phases of this process students can consult all the documentation provided in the classroom, including the slides supporting these tasks as well as some lectures about the subject given by the teacher or by invited experts at real-time, through the GH. All tasks described are performed in groups of 3 or 4 students, being the case study available on the cu page in LMS. This enables the application of learning theories, constructivist and cooperative in teaching requirements elicitation.

Figure 1. Proposed model



Synchronous Communication

For synchronous communication, or conference, the system allows the use of any mobile device, with only the minimum features presented above. Users may only enter the conference / lecture if they have done the previous registration in LMS where the entire structure of the course is described. This communication is ensured through the use of GH given his nonexistent cost, since it is integrated into the applications provided by Google. In this system the result is the most fruitful possible conversation between teachers and students that is held in predefined periods, or upon request, in order to clarify the largest possible number of questions from the students.

To clarify questions, the use of Google Talk (GT) and/or GH tools allows the interaction between students or even between students and their teachers. Thus, for a better organization of the TLP, moments specially planned to clarify doubts are defined at the beginning and/or at the end of the lectures.

Slides

Slides of the classes are especially designed for mobile devices. When a student is using this learning, slides are read / analyzed frequently. Thus, it is required that the file size is small, enabling a transition between them quickly. This is a practical matter and should be taken into consideration for its use on mobile devices. Normally, in this type of environment, slides should contain only the main information that can be easily found, and also follow the main points of the subject to be taught in each module. The general requirements for the development of the slides for mobile devices, as shown at Figures 2 and 3, are as follows: (i) shall include an adequate number of characters and graphics that are sufficiently clear, and (ii) must be readable and understandable in both orientations, horizontal or vertical.

This idea has some advantages. First, the entire file is very small and has two valences, one for online study by Google Presentation (GP) tool and another for offline study (through the file in PDF format). Second, slides must be readable / analyzed on mobile devices that support the most current operating systems – Ubuntu (Linux), iOS (Apple) and Windows (Microsoft).

Videos

With the advent of MOOCs, and recorded lectures, and available by most large HIEs, it is natural

Figure 2. Our sample slides: (a) and (b) Slides on an iPhone horizontally and vertically

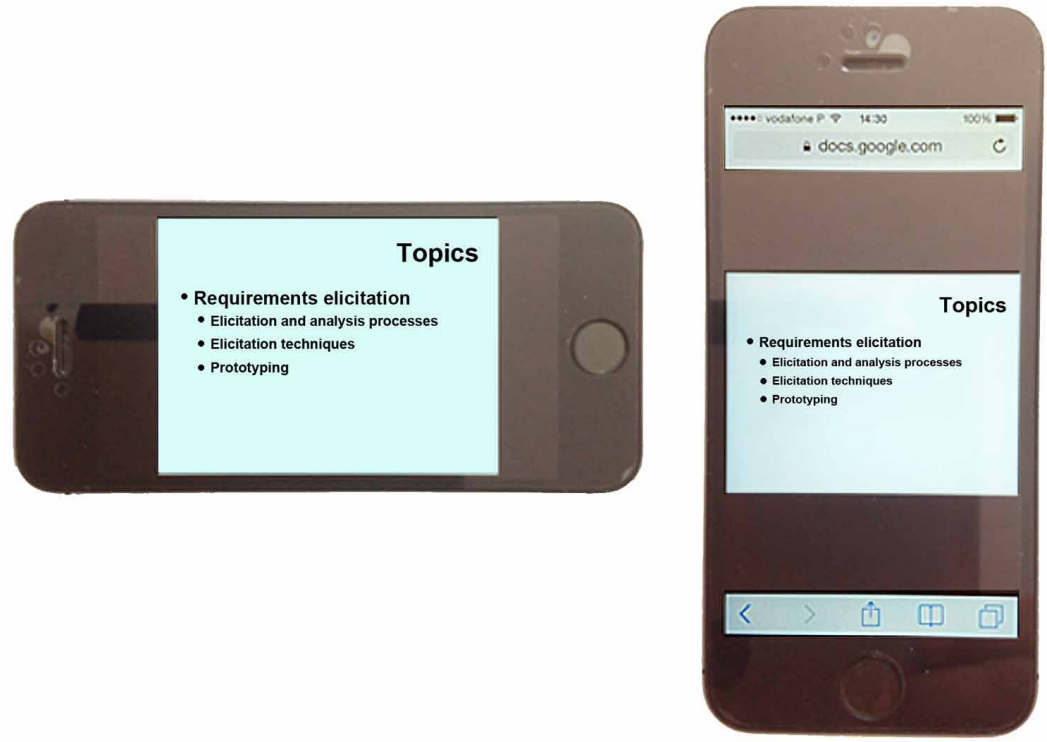
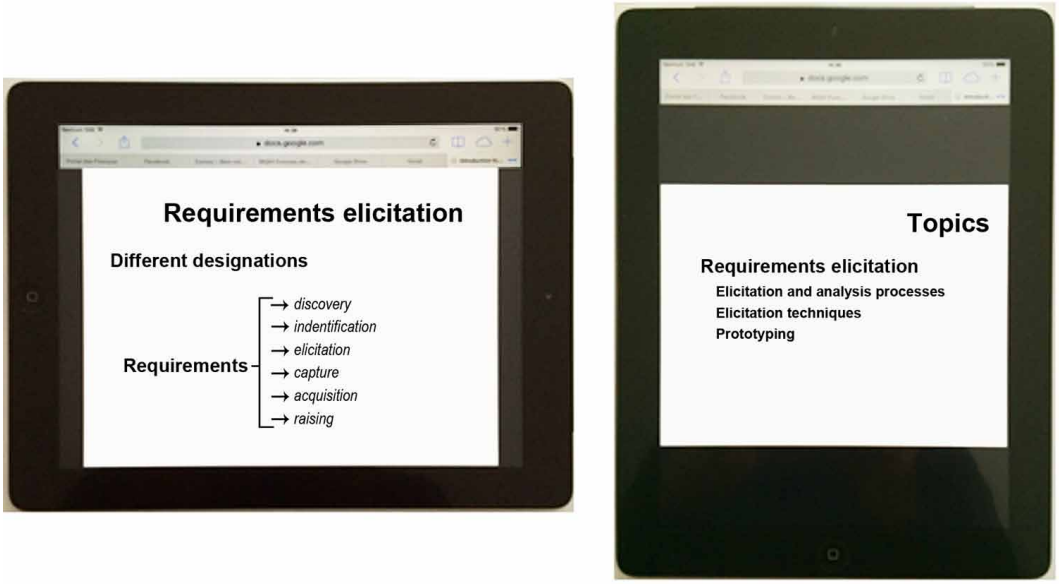


Figure 3. Our sample slides: (a) and (b) Slides on iPad horizontally and vertically



that this approach has a mandatory character in almost any course that uses mobile devices. In this case small classes / lectures, pre-recorded made available on the LMS HEIs, and related to this subject, as well as details of references of free access given by specialists will be used. For a better understanding of the lecture, students are forwarded to recorded sessions, and references available in LMS of the institution, or materials freely accessible on the Internet, e.g. classes from other recognized authors / teachers available on YouTube. The combination of these two possibilities (slides and videos) allows students a greater variety of ways to study for understanding the requirements elicitation thematic.

Questions, Discussion Forum, and Surveys

The questions that students need to make can have two parts, a synchronous or asynchronous. Regarding first case an asynchronous communication with the teacher is accomplished through the use of the GT or GHs. In the second case, students and teachers use the Forum LMS Moodle. Concerning knowledge surveys, Wirth & Perking (2005) had shown the success of its use. They propose that knowledge surveys capture data from both cognitive and affective domains and provide unique information about student evaluations and bridge with exams. This method is used to collect accurate feedback from the students about their state and progress. Surveys are used to direct students towards custom paths that can be followed according to their level. Pre-knowledge survey covers the previous material and following lecture. This allows the student to evaluate his own state. At the same time, it gives ahead warning about what is coming. Pre-knowledge survey provides useful information that allows us to handle students who have diverse backgrounds. Post-knowledge survey gives students the chance to observe their progress during the course of the class. Both knowledge surveys include only qualitative questions.

PRACTICAL APPLICATION

Course Overview

The RE course was designed following the ACM/AIS guidelines and the BT referential. It runs for 15 weeks (one semester) and consists of two hours of theoretical/practice lectures to discuss theory and 2 hours of practice (lab sessions), where students put in practice the learned theory they have learnt.

The main goal of the course is to induce students for the use of RE in their future work as designer in the development of software systems. So, it is expected that a student, at the end of the course, is able to (1) Select and use techniques in requirements engineering process according to the proposed problem; (2) Evaluate and use different techniques for prioritizing requirements according to the problem to be solved; (3) Use a requirements management tool; (4) Recognize technical developments in the area.

In order to meet the proposed goals the programmatic contents are:

1. Overview and Challenges of Requirements Engineering
2. Basic Concepts of the Requirements Engineering
3. The Requirements Engineering Process
4. Requirements Engineering – Process
   a. Elicitation
   b. Analysis, Negotiation and Prioritization
   c. Modeling and Specification
   d. Documentation
   e. Validation
5. Requirements Management - Use of a management requirements tool
6. Future Directions and discussion

The theoretical/practice lectures use the expositive method. However, it is still pretended to have an active participation of students through direct interpellation between teacher and students and vice versa.

In laboratory lectures students must solve case studies that approximate them to the real-world situations. In parallel, students should develop a group project whose goal is to acquire knowledge "Known to do" in a collaborative environment.

In lectures the concepts, techniques and fundamental tools of the RE are discussed in order to provide students a solid foundation that allows them to operate under the current systems and to follow technical developments in the area.

It is intended that each concept, technique or tool presented/discussed in lectures, is put into practice by resolution of Case Studies and a Project which are solved during lectures and afterwards. In turn, the lectures take place in the context of collaborative work, where the ability to group works will be developed.

Proposed Approach

We will follow the set of techniques proposed in (Gutwin, & Greenberg 2002). These techniques allow us to be aware of the other user's cursor position and whether they have selected a text fragment or not, that text will represent a catalogue of requirements. Thus, when a remote user is writing other users it can be observed it in real-time. Additionally, if the user selects some text, it is highlighted by marking it with the selected user's color. In this context, we propose three steps on the "elicitation" task: (1) requirements identification, (2) writing requirements, and (3) discussion.

Step 1: Requirements Identification

The technical requirements elicitation proposed to identify requirements requires the following steps:

1. Read the document which presents the case study;
2. Identify the business processes and mark them with the color blue in case you are using a PC or a laptop, or enter an asterisk (*) at the beginning and at the end of the business process in case you are using a tablet or a smartphone – The main business process leads to functional requirements;
3. Identify the information that a business process needs to manage and support, and mark it with the color green in case you are using a PC or a laptop, or enter a dollar sign ($) at the beginning and at the end of information in case you are using a tablet or a smartphone – this information should also give rise to Functional Requirements;
4. Identify the business rules and tag them with the yellow color in case you are using a PC or a laptop, or insert a number sign (#) at the beginning and at the end of the business rule in the case you are using a tablet or a smartphone;
5. Identify non-functional requirements and mark them with a red color in case you are using a PC or a laptop, or insert a percentage sign (%) at the beginning and at the end in case you are using a tablet or a smartphone.

Step 2: Write Requirements

Complete the identification task requirements. It is expected that students write in a native language catalog requirements by using GF. The student when writing requirements should take into consideration that a requirement should meet the following characteristics: (1) correct, (2) feasible, (3) necessary, (4) prioritized; (5) not ambiguous, and (6) verifiable.

Step 3: Discussion

When students submit the catalog of requirements, the teacher analyzes them and (through the use of GD, GT and GH tools) discusses the proposed solution collaboratively with them.

During these tasks it is proposed to students the use of GD, which shows a list of participants who are editing the same document simultaneously. Using this list, users can communicate with

each other through GT or GH. In this context it is proposed the use of GD to identify and write requirements collaboratively through GF. Then a case study is proposed to students so that they can be present it, following the mentioned approach, and identify and write its functional and non-functional requirements and business rules.

Case Study

In order to operationalize the proposed approach, students will be asked to collaboratively identify and write the requirements and business rules for the case study below, either in fixed or mobile context. The selected theme of the case study is believed to be easily understood by students who should easily understand its system and the business environment.

System Golf Club – *ClubeGolf*

…members renting equipment. A member could be a Full Membership or one of your dependents. When a person makes its registration in the "GolfClub" as a Full Membership, is given the right to nominate up to three dependents, for which is responsible. To the "GolfClub" is critical to identify exactly who rented the equipment, if the Full Membership or one of your dependents. However, for control purposes, the "GolfClub" wants to get more information about the Full Membership than about his dependents. About a Full Membership it is intended to know his name, email address, home phone number, work address, work phone, mobile phone, tax identification number and birth date. Only persons of greater age could Full Membership. From a dependent, only the name, email, birth date and relationship are needed. Both Full Membership and dependents have a registration number, which is single per Full Membership …

Step 1: Requirements Identification

As shown previously, there is the possibility of having students within the classroom and in the outdoors. In Figure 4 is presented an extract from the case study and how to identify the requirements and business rules that can be obtained by using PCs or laptops in the classroom or outside. In Figure 5, the same task may be performed using mobile devices.

Step 2: Write Requirements

Writing requirements and business rules should be implemented through Tables 1 and 2. Such

Figure 4. Requirements elicitation on PCs or laptops

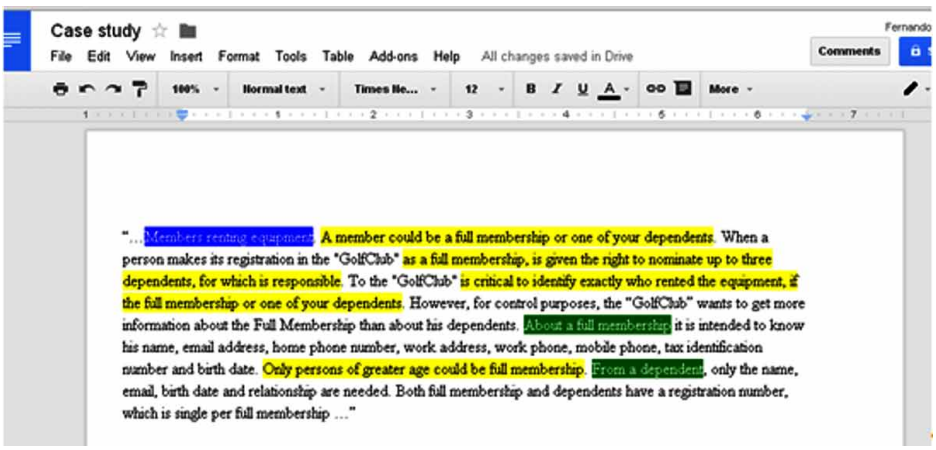
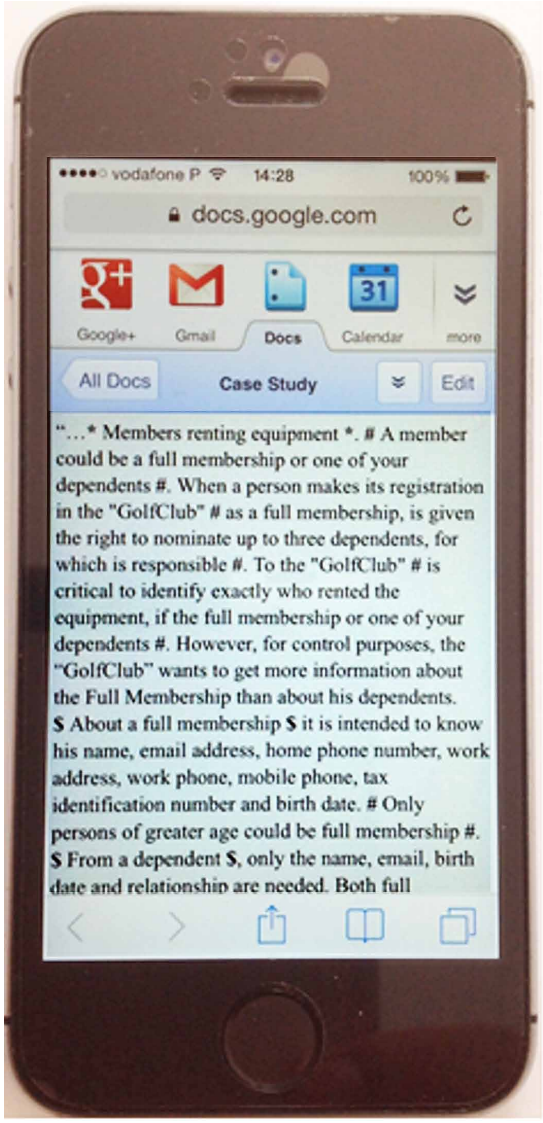


Figure 5. Requirements elicitation in smart phones



tables must contain a different identifier for each type (functional requirements - FR; nonfunctional requirements - NFR; business rules - BR), a description and what is its priority (High, Medium, Low). Only two tables are presented as an example, one for functional requirements and another for business rules (tool used in regular classes). Nevertheless, students use the form of the GF shown in Figure 6.

Table 1. Functional requirements (FR)

ID	FR01
Description	The system should allow the registration of a rent*, registering the full member and the leased equipment, the date / time of rent and the date / time to return the equipment.
Priority	High

* Not included in the displayed text.

Table 2. Business rule (BR)

ID	BR01
Description	There are two types of members: 1. Full member 2. Dependent
Priority	High

Figure 6. Writing requirements in smart phones

Results

The evaluation process was conducted by answering two interviews: one at the beginning of the first semester and another at the end. The first aimed to verify the familiarity between students with the use of mobile devices and applications, as well as to characterize the groups regarding their gender. The second (adapted from (Reis et al., 2014)) aimed to assess the added value of TLP, a particular topic to be taught based on the presented model.

To answer both questionnaires, students were asked to respond by GF. With this tool the results of the questionnaires were obtained immediately.

The results obtained from the first questionnaire, pointed that all student (100%) were male, completely familiar with the use of mobile devices (most students have laptop, smart phone and tablet). Additionally and are very accustomed to using various tools, including tools related to social networking, Google tools and how also expected, games.

The final questionnaire consisted of the following questions:

1. Indicate whether the use of two different interfaces brought some problem in the process of teaching and learning. If you did have had any problem, please explain what it was (they were).
2. How long did it take to start using both tools? Please, explain, why did you spend such time.
3. Do you prefer a web-based tool or an application developed for the operating system platform? Explain what are the reasons for your choice.
4. Indicate if this approach helped you to better understand the issues related to writing requirements.
5. Indicate whether it would be beneficial or not to use such tools in other units of the course.

Almost all surveyed students, 13 (86,6%) believe that the use of two interfaces in the TLP did not present any difficulty, while only 2 (13,3%) indicated that it would be more interesting to use only one interface.

All the students, 15 (100%) indicated that their use is almost immediately, because they were already familiar with both tools.

The students' opinions were split according to the preference of using a web-based or to build a specific system tool. The reasons given in favor of the first option was the transversality of systems and platforms, while the arguments for preferring the second option are performance, speed and essentially the possibility of not being always connected to the Interned solve the proposed activities.

A total of 12 (80%) of students stated positively about the added value that the tool brought to the understanding of this topic, while 3 (20%) indicated that it would likewise understand by the "traditional" method. In last question, the answer was 100% concordant for the benefit of the use of such tools in other courses.

FUTURE RESEARCH DIRECTIONS

Despite the successes and progress to date, many important topics remain open for investigation with respect to providing appropriate techniques, approaches, and tools for requirements engineering teach, including specific assistance for novice students, cognitive support through intelligent tools, and methods that involve direct interaction with stakeholders. Below we have listed some of the potential requirements engineering research areas not completely resolved to date and by the proposed model that we believe deserve appropriate attention:

- Reducing the gap between the theory and practice felt by students
- Increasing the awareness and education of students in this area

- Defining ways of collecting and reusing knowledge about requirements elicitation
- Exploring how requirements elicitation activities relates to new and developing fields of software engineering such as agent based systems, agile development methodologies, and web systems
- Extend the proposed model for all topics set out in section 5.1

More collaboration is still required between research and practice in order to fully evaluate the existing approaches, and develop new ones for emerging problems. Many of the best results in requirements elicitation research achieved so far have come from this type of interaction between work and industry. Awareness and education remain two of the biggest issues faced by those who are working in requirements elicitation.

Students need more practical experience together with theoretical information about RE and they also need to be equipped with a variety of techniques, approaches, and tools to use where appropriate depending on what is best suited to the situation.

CONCLUSION

Organizations have suffered a large (r)evolution at the social, economic and technological levels. The increasing number of mobile devices present in day-to-day of the general population which is more evident among youth people leads to the emergence of new paradigms in several areas of activity, particularly in education.

The elicitation of requisites is one of the topics of requirements engineering that has an important role in the information systems area. Any course of the 1st cycle in Informatics should provide students enough skills for the development of information systems, and requirements elicitation is one of the first steps in the whole process.

With this assumption, there is a need to develop strategies that can provide a more appropriate teaching-learning process to the profile of students arriving today at higher education institutions. As an example of new strategies in teaching-learning process, mobile learning supported by cloud environments and Bloom's taxonomy. Thus tools that can readily be used inside and / or outside the higher education institutions are required. In this context, it is proposed the use of Google tools, aligned with Bloom's taxonomy, the model Blended Mobile Learning-Context Oriented in a requirements engineering course. The proposed model allows students to develop their skills in requirements elicitation using fixed and / or mobile devices easily and flexibly.

The proposed model is based on public domain free tools (easy and accessible to use anywhere and anytime), that helps students in their daily life, inside and outside the higher education institutions and contributes positively in teaching-learning process of the requirements elicitation as presented in the Results section.

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KEY TERMS AND DEFINITIONS

Bloom Taxonomy: Is a classification system used to define and distinguish different levels of human cognition - i.e., thinking, learning, and understanding.

Business Rules: A policy, guideline, standard, or regulation that defines or constrains some aspect of the business.

Cloud Computing: A type of computing, comparable to grid computing that relies on sharing computing resources rather than having local servers or personal devices to handle applications.

Functional Requirements: Describe the functions that the software is to execute. They are sometimes known as capabilities.

Mobile Devices: Is a generic term used to refer to a variety of devices that allow people to access data and information from where ever they are. This includes cell phones and portable devices.

Mobile Learning: Any sort of learning that happens when the learner is not a fixed, predetermined location, or learning that happens when the learners takes advantage of the learning opportunities offered by mobile technologies.

Non Functional Requirements: Are the ones that act to constrain the solution. Nonfunctional requirements are sometimes known as constraints or quality requirements.

Requirement Elicitation: The process through which the customer and developer discover, review, articulate, and understand the users' needs and constraints on the software and development activities.

Requirements: A condition or capability needed by a user to solve a problem or achieve an objective.

Requirements Engineering: Is the science and discipline concerned with analyzing and documenting requirements.

Chapter 13
Multidimensional Assessment of Open-Ended Questions for Enhancing the Quality of Peer Assessment in E-Learning Environments

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ABSTRACT

In online learning environments, peer assessment activities lack the observation and supervision by the teacher or instructor. Therefore, students may be lacked full effort to assess their peers. There exist the students' hesitation about criticizing their peers and scoring their peers honestly, the likelihood for peer assessment to be occasionally unreliable and unfair. The present assessment methods focus only on the single-dimensional assessment of content rather than the activities and collaborations among the students. Students also have no chance to analyze and comment on their peer answers. This study explored the multidimensional assessment method on open-ended question to foster positive attitudes and full effort among students engaging in E-learning environments. The objectives are as follows: 1) To develop a process model for multidimensional assessment (M-DA) to enable effective learning 2) To develop free-text answers assessment by using vector space model and semantic extraction model 3) To develop an algorithm for evaluating students' based on multidimensional assessment. Two groups of parallel students taking an e-course were tested on the system. The results of experiment noted that the proposed method overcomes the method just focuses on student assessment only without consideration and evaluation of the quality of the peer assessment. In light of the findings, the proposed method actively impacted on the development and improvement of learning and the quality of peer assessment among students in E-learning environments.

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INTRODUCTION

In traditional classes, students study and interact in a face-to-face learning environment, so they can learn faster because they are able to seek guidance from their peers and instructors directly. On the other hand, in a traditional class, student studying for an examination supervised by the teacher; tools are appropriately supported for such things as supervision and instruction. Therefore, students are required to study actively and more serious in their approach to the examination. In their class, students can assess and observe each other as well as obtaining feedback and guidance from their teachers or peers. Conversely, the online learning environment lacks of an observation and an appropriate environment to accommodate students to study actively. The barriers still exist which inhibit the efficiency of online teaching and learning (Assareh & Bidokht, 2011; Wong, 2007). Students are required to complete a test based on question types, namely multiple choice, true/false, short answers, matching, and so on. This holds not fully significance when regarding assessment because the accurate comprehension levels of students is only known by assessing their free-text answers. Moreover, students are less self-awareness when they are studying in a virtual learning system without teacher observation.

The assessment in E-learning is facing lack of assessment quality and interaction among students, which hinder students learning. To enhance qualitative evaluation of knowledge and skills of students, there are some assessment techniques that have been researched and published to support the assessment of free-text answers. For example, in (He, Hui, & Quan, 2009), (Alfonseca & Pérez, 2004), (Zhang, Yoshida, & Tang, 2008), etc. However, these assessment methods just focused on enhancing the accuracy of assessment on free-text answers. The assessment contents were put at the centre of method instead of students' activities and interactions to enhance learning efficiency. The current assessment on open-ended question is also one-dimensional assessment. One-dimensional assessment just focuses on the assessment contents rather than the students' activities and interactions among students.

In addition, Peer assessment (PA) has a lot of usefulness in teaching and learning processes. It improves learning, self-assessment capabilities and helps students identify their weak and strong points in their studying, and also fosters collaborative learning. For example, the authors in (AlFallay, 2004; McGarr & Clifford, 2012; Zundert, Sluijsmans, & Merrienboer, 2010) researched on psychology and attitudes of students of peer assessment; Elliott et al. in (Elliott & Higgins, 2005) used self and peer assessment to evaluate contributions of members in a group work, and the authors in (Cho & MacArthur, 2010; Gielen, Peeters, Dochy, Onghena, & Struyven, 2010) analyzed and evaluated the effectiveness of peer feedback for learning and writing revision.

Online PA makes peer assessment more efficient, freedom of time and space for student assessment, ensures anonymity, and facilitates willingness to critique. Online peer assessment was used to develop science activities (Lu & Law, 2012; Tsai & Liang, 2009), to assess the students' projects (Tseng & Tsai, 2007), and to improve science writing (Liang & Tsai, 2010). In (Yu & Wu, 2011a, 2011b), the authors designed an online system with multiple peer-assessment modes to assess their designing questions to improve making question skills.

However, online peer assessment has several disadvantages, including students' hesitation about criticizing their peer (Kaufman & Schunn, 2011), students' fear of scoring their peers honestly, the likelihood for peer assessment to be occasionally unreliable and unfair (Papinczak, Young, & Groves, 2007; Strijbos & Sluijsmans, 2010), and the limited ability to evaluate the work

produced by peers (Topping, 2010; Wen & Tsai, 2006). Thus, it is critical to develop assessment techniques that foster positive attitudes and full effort among students engaging in E-learning environments. Hence, this chapter focused on researching to enhance learning efficiency and assessment activities, and it has the contributions as below.

1. Designing a multidimensional assessment method to assess free-text answers.
2. The method can use to assess free-text answers and enhance the quality of peer assessment in E-learning environment.
3. This assessment method can make students to take full responsibility for their peer assessment activities by its evaluation criteria.

The study has designed an assessment method which can support peer assessment to enhance collaborations, assessment activities of students by multidimensional assessment (M-DA) of free text answers.

BACKGROUND

Peer and Self-Assessment and Online Collaborative Learning

The Impacts of Peer Assessment on Learning

Peer assessment has been a focus of research since the 1990s and has gained considerable recognition as an alternative pedagogical and assessment tool for the promotion of learning (Yu & Wu, 2011b). Specifically, students tend to work harder when they know that they be assessing their peers (Majdoddin, 2010). Peer assessment gives students a sense of ownership over the assessment process, fosters their motivation, improves learning, and turns assessment into a part of the learning process (Tillema, Leenknecht, & Segers, 2011). Through peer assessment, students can identify their strengths and weaknesses in their learning, improve their self-assessment ability, and engage in deep and meaningful learning. In addition, peer feedback can encourage collaborative learning through dialogues about what constitutes good work and through the process of helping each other to make sense of gaps in their learning and understanding. As a result, students reach a more sophisticated understanding of the learning process (Gielen et al., 2010; Kollar & Fischer, 2010). In particular, students who receive feedback from their fellows are exposed to a wide range of ideas about their work, which promotes further development and improvement (Ako, 2012). In the present study, peer assessment is used as both a learning tool and an assessment tool. Peer assessment is considered a learning tool because students tend to observe their peers' work more when they are asked to assess the work. Peer assessment is an assessment tool because students' responses to assessment questions are collected and analyzed (Kilic & Cakan, 2007). It is worth noting that peer assessment has been a positive contribution to student learning and learning processes.

Peer assessment practices have been developed and applied across multiple areas with different characteristics. There are some researches in (AlFallay, 2004; McGarr & Clifford, 2012; Zundert et al., 2010), the authors focused on the psychology, personality traits and attitudes of students in relation to peer assessment and its effectiveness. These studies revealed positive attitudes among the majority of respondents, who felt that peer assessment was valuable and enjoyable. Authors in (Elliott & Higgins, 2005) used self and peer assessment to evaluate the level contribution from members in the context of group work. In this study, stu-

dents demonstrated ability and fairness in their assessment, and peer assessment had a positive impact on student motivation. Meanwhile, in (Cho & MacArthur, 2010; Gielen et al., 2010), they analyzed and evaluated the effectiveness of peer feedback in the domain of learning and writing revision; researchers provided guidelines on the use of the feedback for students and discussed the ways in which feedback was related to revisions and writing quality. In (Rush, Firth, Burke, & Marks-Maran, 2012; Tsivitanidou, Zacharia, & Hovardas, 2011), authors focused on the skills of peer assessment by evaluating secondary school students' unmediated peer assessment skills, peer assessment of clinical skills among first-year nursing student and peer assessment of professionalism. The findings show that students hold positive attitudes toward unsupported reciprocal peer assessment and that there is a positive impact of clinical skills on their learning skills. Kovach et al. (Kovach, Resch, & Verhulst, 2009) used peer assessment to evaluate the level of professionalism among fifth-year students in medical clerkship, finding that both students and faculty accept peer assessments as a meaningful aspect of student evaluation.

The authors in (Papinczak et al., 2007; Topping, 1998) published commentaries and analyses of peer assessment, in which they point out both advantages and disadvantages of peer assessment. On the one hand, peer assessment present many advantages in terms of improving learning, developing peer assessment skills, increasing responsibility for others, collaborative learning and so on. On the other hand, disadvantages exist such as students' hesitation about downgrading and criticizing their peers, students' fear to honestly mark their peers, and the likelihood for peer assessment to be occasionally unreliable and unfair. The authors also mentioned the need to develop methodologies, concepts, functions and techniques to facilitate and enhance peer assessment.

Peer Assessment in Collaborative Learning

Peer assessment has important role in promotion of collaborative learning, and collaborative learning also provides an opportunity for the development of interpersonal and group work skills, such as communication, guidance, planning, and time management (Lee, 2008).

In (Mello, 1993), Mello revealed that, through collaborative learning, the students gained an insight into group dynamics and processes, developed their interpersonal skills, exposed the viewpoints of other group members, and they could easily explore their work than by traditional classroom methods alone. Resta et al. (Resta, Awalt, & Menchaca, 2002) pointed out that the reasons for using peer- and self-assessment in collaborative learning environments were, (1) collaborative learning was based on understanding that learning was a social process best done in groups; (2) the need to provide group members to account for completion their learning tasks; (3) the need to establish positive interdependence of group members for successful collaborative learning environments; (4) collaborative learning was only based on cooperation work, it therefore involves a process formative assessment is more suitable; (5) students had the opportunity to use the assessments to help them improve their performance as a group member; and (6) students had a chance to learn how to assess their work in a group over a sequence of work.

The effects of peer assessment in collaborative learning claimed by several studies. In (DeNisi, Randolph, & Blencoe, 1983), peer assessment can affect individuals' perceptions about the cohesiveness and performance of their groups. The peer appraisals can have a positive influence on a group's ability to work well together and on group members' satisfaction with the group (Druskat & Wolff, 1999). In (Li & Steckelberg, 2006), they investigated students' perceptions

and attitudes toward online peer assessment and revealed that students receive feedback from peers helping them to reconsider and improve their work. Online peer assessment makes the opportunity to review and grade their peers' performances that urge students to observe the contents that they are being assessed. The online peer assessment system provides anonymity for students easily to assess and criticize their peers work. Lee investigated factors that affect students' perceptions of the use of online peer assessment in an online collaborative learning environment, and explore how the assessments impact student online collaboration (Lee, 2008). Peer assessment has reciprocal relationships with the collaborative learning in online learning environment to promote the development and improvement of learning and assessment skills among students.

Techniques and Online Systems Supporting Peer Assessment

The rapid advancement of internet technology is bringing about a dramatic shift in the practice of education (Tseng & Tsai, 2007). As anticipated by Topping, computer-aided peer assessment has become an emerging growth area (Topping, 1998). Online peer assessment can improve the effectiveness of peer assessment and minimize time and space related constraints on student assessment. The authors in (Li & Steckelberg, 2004) presented a system that supported online peer assessment. In the context of WebQuests, the system allowed each student to review the work of and receive feedback from two fellow students, after which the students revise their WebQuests base on the peer feedback. The results show that both teachers and students generally acknowledge peer assessment as a valuable process that foster critical thinking skills and promoting meaningful learning among students. Authors in (Lu & Law, 2012; Tsai & Liang, 2009) also used online peer assessment to develop science activities and analyzed the cognition and effectiveness of feedback in relation to the quality of the projects for both assessors and assessees. In (Yu & Wu, 2011a, 2011b), an online system with multiple peer assessment modules was designed to allow students to evaluate the appropriateness of questions designed by their peers. Through this system, students are able to improve their assessment and question writing skills. Students' perceptions and attitudes about peer assessment were studied through online peer assessment systems by (Kaufman & Schunn, 2011; Wen & Tsai, 2006). The results revealed positive attitudes among students toward the use of peer assessment activities, although negative attitudes (such as the feeling that peer assessment was unfair and unqualified to assess their work) were also observed. Another online peer assessment system was used for peers to assess student projects that involved the planning of a one-day trip in six weeks. Each student project is assessed in three rounds. In each round of peer assessment, each student receives ten comments and scores from his/her peer assessors. The results show that the feedback is useful in helping students to develop and improve their projects, and that the correlation between the scores from two teachers and the scores from students increases as the students engaging in more rounds of peer assessment (Tseng & Tsai, 2007).

In addition to applying online peer assessment systems to various areas, researchers have also focused on proposing techniques that enhance the quality of online peer assessment activities. Chang and Chen in (Chang & Chen, 2009) developed a fuzzy peer assessment system to satisfy the requirements of interactive and cooperative learning in an E-learning environment. A web-based mobile assessment participation system was designed by Chen (Chen, 2010) to support self- and peer-assessment. This system facilitated the effectiveness of self- and peer-assessment by way of the more efficient

use of time, portability, peer interaction and opportunities for student reflection on learning and assessment. Another approach, presented by Wever et al., focused on the impact of peer assessment on student collaboration and learning activities in a wiki environment (Wever, Keer, Schellens, & Valcke, 2011).

In higher education, open-ended questions are usually used in teaching to assess students' perceptions through their free-text answers. There are several methods that use to automate the assessment of free-text answer e.g., (Assareh & Bidokht, 2011; Liu, Bao, & Xu, 2011; Wong, 2007). Moreover, free-text answers are also used for peer assessment system to enhance student learning and assessment skills. In (M., C., & Helic, 2009), the authors used an online peer assessment system to assess short free-text responses submitted by students. However, being merely an online assessment system that supported peer assessment of free-text answers, this system was unable to automatically evaluate student answers and simultaneously account for the results of peer assessment.

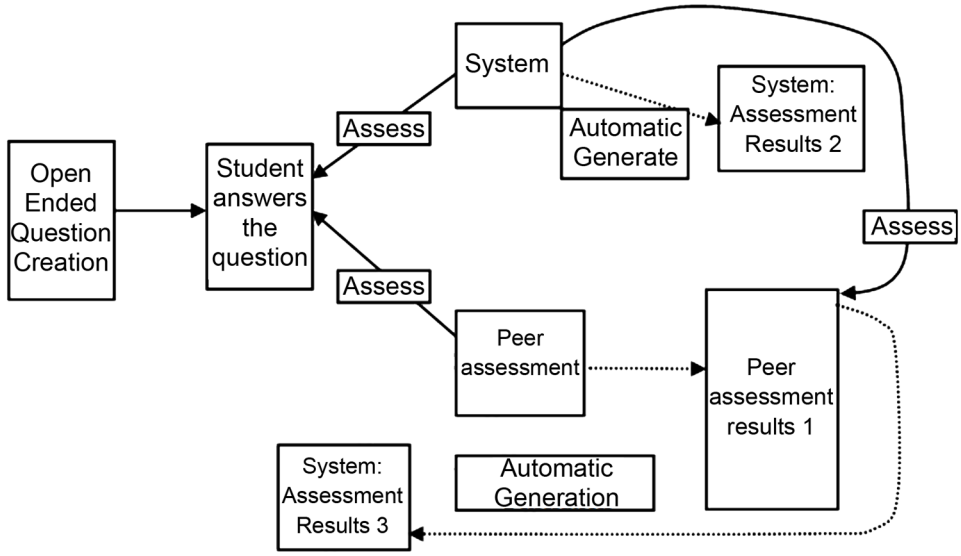
In summary, a considerable number of online systems are available today to support peer assessment across many areas with many advantages, such as ensuring anonymity and fostering the willingness to critique. Additionally, students are able to assess, collaborate and learn together anywhere at any time. Moreover, peer assessment has been found to improve student learning, thinking and assessment skills. Nevertheless, the techniques that enhance the quality of peer assessment are still scattered, and the limitations of online peer assessment systems persist. For example, the quality of peer assessment is inadequate for the grading of students. Several studies have suggested that students experience negative attitudes, such as a reluctance to downgrade and criticize their peers and, occasionally, the sense that peer assessment can be unreliable and unfair (Kaufman & Schunn, 2011; Papinczak et al., 2007; Wen & Tsai, 2006). Furthermore, in online learning environments, the teacher is unable to observe student work. Specifically, existing online peer assessment systems lack the tools to allow control over peer assessment activities and enable the evaluation of the quality of peer assessment. Peer assessment activities may influence student assesse scores and have no direct impact on assessor score, given that peer assessment can sometimes be perfunctory, that students can remain low on self-awareness and passive in knowledge sharing, and that a minority of students do not even pay attention to assessment and learning.

Multidimensional Assessment

In light of the above disadvantages, a novel assessment method was proposed that is called multidimensional assessment. Multidimensional assessment is combined three dimensions of assessments (system assessment of students' free-text answers, peer assessment of students' free-text answers and system assessment of the peer assessment; see in Figure 1) in order to enhance the quality of learning and peer assessment based on collaborations and activities in E-learning environments (Alfonseca & Pérez, 2004; Hoang & Arch-int, 2013). The detailed model and assessment techniques are presented in the next section.

In this study, we propose a novel peer assessment method that supports for enhancing the quality of peer assessments, learning activities, assessment skills, and the attitudes that are involved in the process of peer assessment. According to this method, students are offered an online environment in which they can easily answer open-ended questions at their chosen time and place. To encourage critical feedback, the students respond to questions anonymously. Furthermore, to minimize the time and effort that is required of the teacher for assessment, the system automati-

Figure 1. Multidimensional assessment model



cally scores open-ended responses that are written by each student. More specifically, the system can automatically assess the results of each student's assessment of others' answers. The final score for each student is calculated based on each student's own answer and his or her assessment of the peer responses. A student who can evaluate and score peer responses in a way that resembles the system receives an additional score. Moreover, if a student pays attention during their assessment, they will give an assessment that is more accurate. The experimental results will analyze and evaluate how proposed method improves the quality of peer assessment results and peer assessment activities.

SOLUTIONS AND RECOMMENDATIONS

The purpose of this study was to investigate the assessment method to assess student free-text answers, and provide multidimensional assessment for peer assessment to enhance learning efficiency of activities and collaborations, and peer assessment attitudes in E-learning environments.

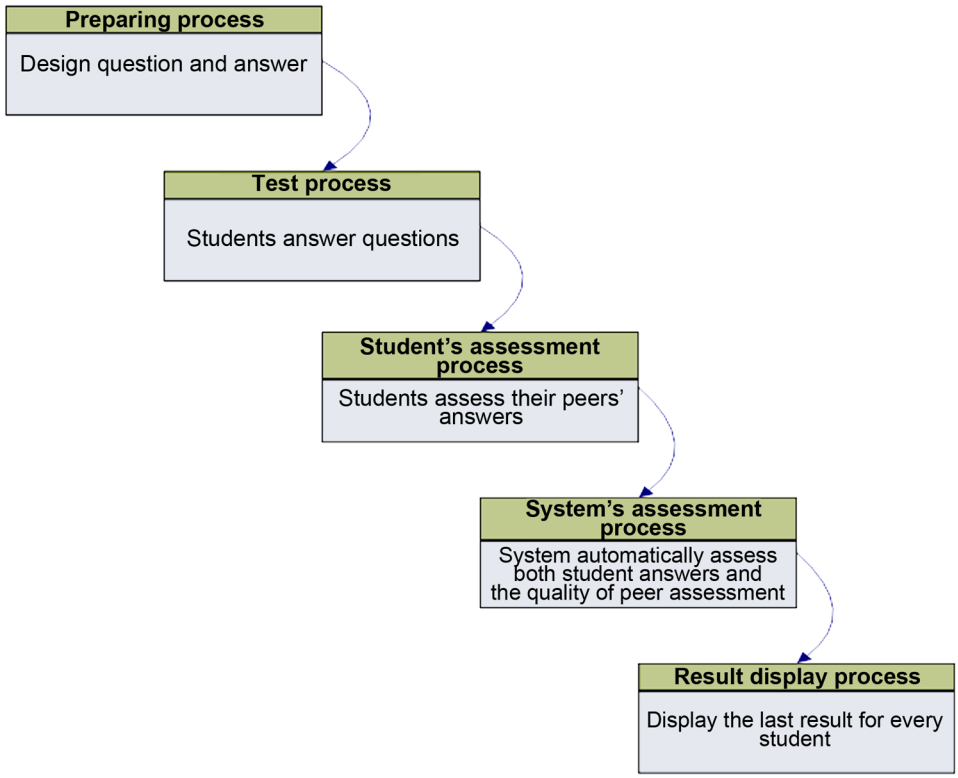
A Process Model for Multidimensional Assessment

In the scope of this research, multidimensional assessment is considered and assessed in three dimensions, which are a system assessment of each student's answer, students' assessment of their peers' answers and a system assessment of the quality of peer assessment. However, this work can be extended with other dimensions such as we assess student knowledge contribution, position of the student in social learning site, and more.

This section proposes a process model for multidimensional assessment that presents an outline of the assessment process. The process model consists of several sub-processes, as shown in the Figure 2 and can be described as follows:

- **Preparing Process:** Teacher uses this process to provide questions, answers and time, etc. for students' assessment and answer.
- **Test Process:** Students use this process to answer questions from the preparing pro-

Figure 2. A process model for multidimensional assessment



cess. In this process, students have to complete the questions within the limited time.

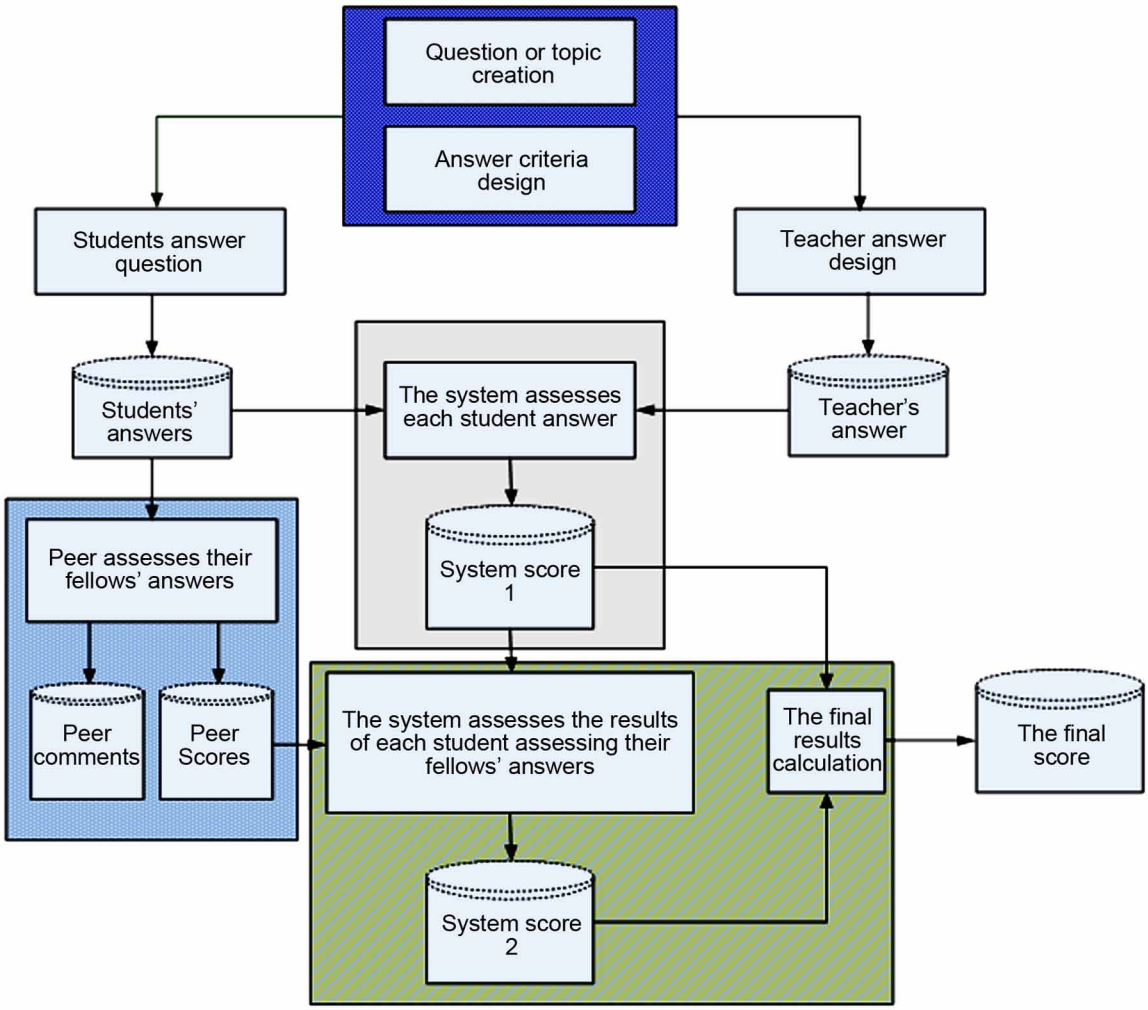
- **Student's Assessment Process:** This process is used for each student to assess other students' answers during the time interval. This process aims to enhance interactions and collaborations between students.
- **System's Assessment Process:** In this process, the system automatically assesses the students' answers and results of the students assessing the others' answers. This process encourages students to interact and study actively.
- **Result Display Process:** For this final process, the system calculates and generates the last result and displays feedback for each student.

The assessment of students' process and the assessment system process are described in details in the next section.

The Conceptual Framework of the Multidimensional Assessment System

This study proposes the multidimensional assessment (M-DA) method which does not only assess the students' answers, but also provides an environment to support students' interaction in assessing other students' answers. The components of the assessment approach have reciprocal relationships, as shown in Figure 3. The assessment approach includes three main sub-assessment components: a system assessment of each student's answer,

Figure 3. The conceptual framework of the system



students' assessment of their peers' answers and a system assessment of the quality of peer assessment. According to the proposed assessment, it can use as an active method to assess and teach new concepts for both high school and university students in E-learning environment. Additionally, this assessment requires students to have skills using computer and critical skills. Hence it is so hard to use in the primary school or kindergarten.

The conceptual framework of M-DA consists of several components as illustrated in Figure 3. Each component is described as following:

Question or Topic Creation

Teachers can use this function to create topics or open-ended questions that are not only used to assess students when finish the e-course, but also as a topic or an exercise for students to study and discuss together during the time they are learning.

- **The Answer Criteria Design:** This function is designed to enhance method that creates numerous reference answers for each question as mentioned previously in

the related work section. The answer criteria are used as a guideline for students to answer the question in a correct way, and avoid some trivial mistakes that can affect to the assessment results by means of assessment techniques.

The answer criteria are designed to contain two parts:

1. **Estimate size:** The estimated number of words for each answer.
2. **Description order of answer:** The order of paragraphs, sentences or functions in each answer (instruction for each answer).
   Example: The question – What is an operating system?

The answer criteria for this question contain:

1. **Estimate size:** about 80 words.
2. **Description order of answer:** definition, functions of operating system.

Using the answer criteria, students have to answer questions according to this answer criteria design. Hence, students' answers and teacher's answer have not much difference regarding syntaxes and size. Therefore, the similarity of students' answers and teacher's answer are improved, and scores of assessment results are more accurate.

- **Teacher Answer Design:** This function allows teachers to write the answer of each question conforming to the answer criteria design.
- **Students Answer Questions:** This function allows students to answer questions conforming to the answer criteria design.

Students' Assessment of Their Peers' Answers (Peer score, Peer comment)

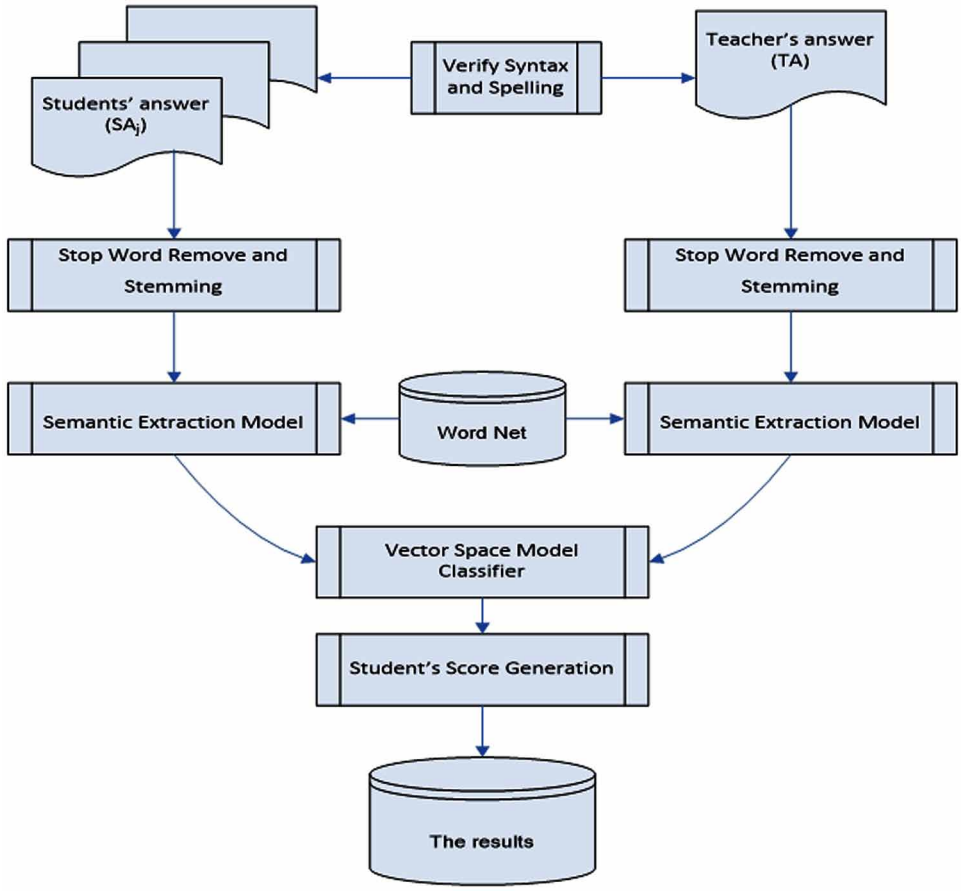
This function allows students to assess and debate each other. Student participants assess their peers' answers once every student has answered the question completely. With every given question, each student assesses the answers from five of their peers, chosen randomly. Students assess their peers' answers by means of comment and score, peer comment is generated based on the inclusion of correct information and incorrect information, according to a marking scheme with a maximum score of 10 (0=<score<=10). For example, $student_i$ assesses $student_j$'s answer with Peer $score_{i,j}$ and Peer $comment_{i,j}$. ($i, j = \overline{1,n}$, $i \neq j$, because each student cannot assess his or herself). To avoid any influence on student judgment, the system-generated scores are not revealed during the process of peer assessment activities. We have Peer $score_{j,i}$ and Peer $commnent_{j,i}$ respectively when $j=i$ and $i=j$. Through these activities, students can archive the knowledge of the E-course.

The System Assessment of Each Student's Answer (System score1)

The system automatically assesses each student answer and generates System score1 by matching student's answer with teacher's answer. The assessment process on free-text answers is presented in detail in Figure 4. The design of the assessment process consists of several sub-processes as follows:

- **Syntax and Spelling Verification:** This module is used for receiving and verifying syntax and spelling of the students' answer

Figure 4. An overview framework for automatic assessment process on free-text answers



and teacher's answer. This function employs the Java open source spell checker of Jazzy

- **Students' Answering and Teacher's Answering Processes:** These processes support students to answer the question and support the teacher to design answer. Both student's and teacher's answers have to conform to the answer criteria design as defined in Section 2)
- **Stop Word Remove (SWR):** This module is used for removing the stop words, such as prepositions, conjunction, punctuations and special symbols in a sentence of both student's and teacher's answers. These stop words need to be removed before the free-text answers are processed in the next step.
- **Stemming:** This module is used for extracting the root word from words, such as plurals and gerunds. Stemming is an important step in free-text assessment. This module can employ Porter stemming algorithm[1].
- **Semantic Extraction Model:** This module is used to extract terms and terms frequency from teacher's answer (TA) and student's answer (SA), and find the synonymous terms by employing the WordNet database[2]. This process consists of several steps as follows:

- Transform terms from TA and each student answer $SA_c \in SA_i$ into a matrix, and then count each term frequency that appears in TA and SA_c respectively (see the example in Table 1).
- Choose $term_i$ in the matrix that satisfies condition vectors $TA[term_i] <> 0$ and $SA_c[term_i] = 0$ ($term_i$ appears in TA but not in SA_c).
- Find synonymous terms for $term_i$ by WordNet and then obtain a Synset that contains a set of synonymous terms for each $term_i$.
- Compare each $term_j$ in the Synset with $term_k$ that satisfies the conditions $SAc[term_k]<>0$, and $TA[term_k] = 0$ ($term_k$ appears in SA_c but not in TA).
- Choose $term_j$ that is matched with $term_k$ such that, $SA_c[term_k]$ = maximum, and $TA[term_k] = 0$.
- Assign $SA_c[term_i] = SA_c[term_k]$, and then remove $term_k$ from the matrix. After this step, two expanded vectors are obtained, i.e., SA_c vector and TA vector.

- **Vector Space Model Classifier and Student's Score Generation:** This module is used to generate each student's score by utilizing the vector space model formula[3] to calculate the similarity score between each student's answer (SA_j) and teacher's answer (TA) as shown in Formula (1).

$$Sim(LA_j, TA) = \frac{SA_j TA}{\|SA_j\| \, | \, \|TA\|} = \frac{\sum_k W_{j,k} W_{TA,k}}{\sqrt{\sum_k W^2_{j,k}} \sqrt{\sum_k W^2_{TA,k}}} \quad (1)$$

where each $W_{j,k}$ is a weight of the term T_k in SA_j, and $W_{TA,k}$ is a weight of the term T_k in teacher's

Table 1. Example of student's score calculation

Unique Term	*Vectors*		$TF_{c,k}$		IDF_k	*Term weight – TF.IDF* ($W_{c,k}$)	
	TA	SA_c	*TA*	SA_c		*TA*	SA_c
elearning	3	2	0.088	0.074	0.301	0.02649064	0.02227622
electronic	1	1	0.029	0.037	0.301	0.00872987	0.01113811
process	2	2	0.059	0.074	0.301	0.01776077	0.02227622
transfer	1	0	0.029	0	0.4771	0.013836516	0
Skill	1	0	0.029	0	0.4771	0.013836516	0
Web	1	1	0.029	0.037	0.301	0.00872987	0.01113811
Learn	2	2	0.059	0.074	0.301	0.01776077	0.02227622
computer	1	1	0.029	0.037	0.301	0.00872987	0.01113811
virtual	1	1	0.029	0.037	0.301	0.00872987	0.01113811
classroom	1	1	0.029	0.037	0.301	0.00872987	0.01113811
digital	1	1	0.029	0.037	0.301	0.00872987	0.01113811
collaboration	1	0	0.029	0	0.4771	0.013836516	0
content	1	1	0.029	0.037	0.301	0.00872987	0.01113811
deliver	1	1	0.029	0.037	0.301	0.00872987	0.01113811
internet	1	1	0.029	0.037	0.301	0.00872987	0.01113811
…	..	..	..	..	..	...	..
$Sim(SA_c, TA)$						0.793711383	

answer. The weight $W_{j,k}$, and $W_{TA,k}$ are calculated by Formulas (2) and (3) respectively.

$$W_{j,k} = tf_{j,k} * idf_k \text{ or } W_{TA,k} = tf_{TA,k} * idf_k \quad (2)$$

where $tf_{j,k}$ is a frequency of term T_k in j-th answer and is calculated by Formula (3), and idf_k is an inverse document frequency of term T_k in the total number of answers that contain term T_k and is calculated by Formula (4).

$$tf_{j,k} = x_{jk}/N_j \quad (3)$$

where x_{jk} is a frequency of the appearance of the term T_k in j-th answer, and N_j is the number of terms in the j-th answer.

$$idf_k = \log(N/n_k) \text{ or } idf_k = \log(N/(n_k+1)) \quad (4)$$

where N = total number of answers in the answers set, and n_k is the number of answers in which term T_k appears.

Table 1 illustrates how to generate a score of $student_c$ for a question. The last score of $student_c$ calculated by Formula (1) is equal to 0.79371138. This value is converted into the marking scheme with the maximum score = 10 (0=<score<=10), therefore, score of $student_c$ = 7.94.

Peer Scores and Comments

Once the students have answered the question completely, they have to assess their peers' answers and give some comments to each peer. With every given question, every student assesses the answers from five of their peers, chosen randomly. According to a marking scheme with a maximum score of 10 (0=<score <=10), students assess their peers' answers by means of scores (Peer $score_{i,j}$) and feedback; peer feedback includes correct information and incorrect information. To avoid any influence on student judgment, the system-generated scores are not revealed during the process of peer assessment activities.

The System Assessment of the Quality of Peer Assessment (System score2).

In virtual learning environments, the teacher or instructor is unable to observe or conduct peer assessment activities. In light of this constraint, it is important to develop assessment techniques that encourage positive attitudes and full effort on the part of students in E-learning environments. Hence, proposed technique focused on evaluating the accuracy of peer assessment, which is integrated into the final score of each student.

To generate the score (System score2) for peer assessment, Euclidean distance and mark technique are applied to generate the formula for System score2 of each student as shown in Formula (5) as shown below:

$$System\ Score\ 2_{i,j} = \text{Max} - |System\ Score\ 1_j - Peer\ Score_{i,j}| \quad (5)$$

where System score2 is the system-generated score for the accuracy of peer assessment; Max is the maximum score in the marking scheme. In this study, Max = 10 (0=<score<=10). System score1 is the system-generated score for $student_j$ answer, and Peer $score_{i,j}$ is the score for the $student_i$ assessing the $student_j$'s answer, $i,\ j = \overline{1,n}$ and i≠j. With a given question, $student_i$ assessed five of their peer and is, therefore, evaluated five times on System $score2_{i,j}$. The final System score2 of each student represents the average of the five scores.

The Final Score Calculation (FSc_student)

The final score of each student (FSc_student) is computed as follows:

$$FSc_student_i = (System\ Corel_i) * \gamma + (\text{Average}(System\ Core2_{i,j})) * \delta \quad (6)$$

where γ and δ are coefficients or important weight values of system scores of student answers and system scores of peer assessment responses, respectively. For this study, because system scores of student answers are very important in learning evaluation, this study sets the values of γ at 0.8 and δ at 0.2 where γ+δ=1. Depending on the target evaluation, however, instructors or teachers can adjust the appropriate weight values.

The Multidimensional Assessment Algorithm

This section illustrates the overall algorithm for the multidimensional assessment method as shown in the Multidimensional Assessment Algorithm. This algorithm points out the steps to assess and calculate the final score for each student in multidimensional assessment scheme as described below:

Lines 1 to 6: These steps prepare the assessment setting environment.

Lines 7 to 10: These steps perform the automatic assessment process on free-text answers and calculate System score1$_j$ for each student$_j$.

Lines 11 to 17: These steps perform the multidimensional assessment between students. We apply Formula (5) to calculate *System core2*$_{i,j}$ of student$_i$ assessing the student$_j$'s answer. When i=j and j=i, the *System score2*$_{j,i}$ is also calculated.

Lines 18 to 22: These steps sort *System score2*$_{i,j}$ in descending order.

Lines 23 to 29: These steps select the maximum m scores of the *System score2*$_{i,j}$ and sum for these m scores (In this study, we set m =5).

Lines 30 to 33: These steps calculate the final scores for each student and report to each student. The final scores are calculated by employing Formula (6). For these steps, if a student$_c$ ∈ student$_i$ assesses other students with scores related or closed to the *System score1*, the student$_c$ will obtain the high final score. This aims to encourage each student to actively assess other students and give chance for each student to discuss with other students.

To serve as an example to ease understanding, Table 2 and Table 3 illustrate concrete example by employing the multidimensional assessment algorithm. Table 2 provides a question and an answer criteria design as given in the first row, and the teacher's answer is given in the second row.

Table 3 presents the Peer score, System score1, System score2 and the final score for six students. Concretely, in Table 3, the first column contains several students' answers. The second column contains results of each student assessing their peer answers. The system automatically assessed both of students' answers and results of students assessing their peers, and then provided results in Column 3 and Column 4 respectively. The last column contains the final students' scores. In this example, the highlight numbers illustrate the calculation of System score2, and the final score of student1. For other students, the System score2 and final score are calculated in a similar way.

Following chapter, it presents how the experiment setting is organized and how proposed method is evaluated.

EXPERIMENT SETTING AND FINDINGS

Participants and Experiment Setting

Participants consisted of 40 first-year students (16 male, 24 female, with an average age = 19.2) in the second semester recruited from a class of students studying informatics at Quang Tri Teacher Training College, Vietnam. Students training in informatics were chosen due to their need to become more knowledgeable about informatics and assessment skills and to develop a deeper

Algorithm 1. The Multidimensional Assessment

Input: Students' answers, teacher's answer and results of students assessing each other.			
Output: Assessment results of students.			
Method:			
1.	*Create question and answer;*		
2.	*Set time for students to answer question;*		
3.	*Organize students to answer question;*		
4.	*Set time for students to assess others' answers;*		
5.	*Peer score$_{i,j}$ is score of the student$_i$ assessing the student$_j$'s answer i, j = 1..n, i ≠ j;*		
6.	*Let Peer comment$_{i,j}$ is comment of the student$_i$ assessing the student$_j$'s answer;*		
7.	*For each SA$_j$ Do*		
8.		*Perform the system assessment of each student's answer*	
9.		*Let System core1$_j$ is score of the system assessing the student$_j$'s answer, j = 1..n;*	
10.	*Endfor;*		
11.	*For each System score1$_j$ of the student$_j$ Do*		
12.		*For each Peer score$_{i,j}$ of the student$_i$ assessing the student$_j$'s answer (i ≠ j) Do*	
13.			*System calculates System score2$_{i,j}$ of student$_i$ assessing the student$_j$'s answer via formula (5);* *//System score2$_{i,j}$: score of the system assessing result of student$_i$ assesses //student$_j$'s answer* *//if i=j and j=i then System score2$_{j,i}$ is also calculated.*
14.		*Endfor;*	
15.	*Endfor;*		
	// Sort the System score2$_{i,j}$ in descending order		
16.	*For every student$_i$ Do*		
17.		*For every student$_j$ is assessed by student$_i$ Do*	
18.			*Sort System score2$_{i,j}$ in descending order;*
19.		*Endfor;*	
20.	*Endfor;*		
21.	*Student$_i$.Sum_Score_2 = 0;*		
22.	*For every student$_i$ Do*		
23.		*For student$_j$ is assessed by student$_i$ Do*	
24.			*//We choose the top of m values of System scores2$_{i,j}$ of student$_j$* *Student$_i$.Sum_Score_2 = Student$_i$. Sum_Score_2 + System score2$_{i,j}$;*
25.		*Endfor;*	
26.	*Endfor;*		
27.	*For every student$_i$ Do*		
28.		*Student$_i$.final_score = System score1$_i$*γ + ((Sum_Score_2 of studenti/m)*δ;*	
29.	*Endfor;*		
30.	*For every student$_i$ Do*		
31.		*Display(The final result of student$_i$);*	
32.	*Endfor;*		
33.	*Return;*		

Table 2. Example of question and teacher's answer

Question:	What is an operating system? *The answer criteria design: {Estimate size: about 80 words}, {answer order: definition, functions}*
Teacher's Answer:	An operating system is a software program or set of programs that mediate access between physical devices and application programs, and so on.

Table 3. Example of multidimensional assessment results

Student$_i$'s answer	**Student$_j$ assesses student$_i$'s answer with Peer score$_{j,i}$ (i≠j)**	**System score1 of student$_i$'s answer**	**System score2 of student$_j$ assessing student$_i$'s answer**	**The final score of student$_i$**
Student$_1$'s answer	Peer score$_{2,1}$: 9.0 Peer score$_{3,1}$: 4.0 Peer score$_{4,1}$: 8.0 Peer score$_{5,1}$: 1.0 Peer score$_{6,1}$: 6.0	System score1$_1$: 9.0	System score2$_{2,1}$: 10 System score2$_{3,1}$: 5.0 System score2$_{4,1}$: 9.0 System score2$_{5,1}$: 2.0 System score2$_{6,1}$: 7.0	The final score of student$_1$ = 9.0*0.8+ (average(9.0, 10, 9.3, 7.7, 9.0))*0.2 = 9.0
Student$_2$'s answer	Peer score $_{1,2}$: 8.5	System score1$_2$:9.5	System score2$_{1,2}$: 9.0	9.4
	Peer score$_{3,2}$: 4.5		System score2$_{3,2}$: 5.0	
	Peer score$_{4,2}$: 8.5		System score2$_{4,2}$: 9.0	
	Peer score$_{5,2}$: 1.0		System score2$_{5,2}$: 1.5	
	Peer score$_{6,2}$: 7.5		System score2$_{6,2}$: 8.0	
Student$_3$'s answer	Peer score$_{1,3}$: 4.5	System score1$_3$:4.5	System score2$_{1,3}$: 10	4.8
	Peer score$_{2,3}$: 3.5		System score2$_{2,3}$: 9.0	
	Peer score$_{4,3}$: 7.5		System score2$_{4,3}$: 7.0	
	Peer score$_{5,3}$: 9.5		System score2$_{5,3}$: 5.0	
	Peer score$_{6,3}$: 8.5		System score2$_{6,3}$: 6.0	
Student$_4$'s answer	Peer score$_{1,4}$: 9.0	System score1$_4$:8.3	System score2$_{1,4}$: 9.3	8.4
	Peer score$_{2,4}$: 6.0		System score2$_{2,4}$: 7.7	
	Peer score$_{3,4}$: 4.5		System score2$_{3,4}$: 6.2	
	Peer score$_{5,4}$: 0.5		System score2$_{5,4}$: 2.2	
	Peer score$_{6,4}$: 7.5		System score2$_{6,4}$: 9.2	
Student$_5$'s answer	Peer score$_{1,5}$: 6.0	System score1$_5$:3.7	System score2$_{1,5}$: 7.7	3.6
	Peer score$_{2,5}$: 2.5		System score2$_{2,5}$: 8.8	
	Peer score$_{3,5}$: 8.0		System score2$_{3,5}$: 5.7	
	Peer score$_{4,5}$: 3.0		System score2$_{4,5}$: 9.3	
	Peer score$_{6,5}$: 7.5		System score2$_{6,5}$: 6.2	
Student$_6$'s answer	Peer score$_{1,6}$: 6.5	System score1$_6$:5.5	System score2$_{1,6}$: 9.0	5.9
	Peer score$_{2,6}$: 5.5		System score2$_{2,6}$: 10	
	Peer score$_{3,6}$: 3.5		System score2$_{3,6}$: 8.0	
	Peer score$_{4,6}$: 5.5		System score2$_{4,6}$: 10	
	Peer score$_{5,6}$: 0.5		System score2$_{5,6}$: 5.0	

understanding of the main concepts of informatics before they became teachers. In addition, students training in pedagogy, compared to other students, were likely to offer more precise evaluations of the proposed technique. In this study, several open-ended questions were designed, which related to concepts of informatics. Based on the questions, the improvement in knowledge and assessment skill among students was assessed. The students were instructed to answer the questions, to score and provide feedback to the answers of five other students per question. In other words, every answer was assessed by five randomly assigned peers. The aim of the exercise was to evaluate the knowledge of the student assessor and to help assessees understand and recognize the strengths and weaknesses about their answers. The entire process of collecting student answers and peer assessment responses to questions occurred over an online course of instruction. Thus, this method not only assessed student answers, but it also served as a pedagogical activity to improve student knowledge and skills in the study process. Students took part in all activities anonymously. The five students chosen randomly for peer assessment of each question were also kept anonymous. This system was expected to facilitate greater anonymity and timely submission.

Prior to the peer assessment activity, participants were separated into two groups of twenty, matched on initial knowledge and skill based on the learning results of the first semester. Students in two groups were independent during learning time. Group 2 participants were informed that their peer assessment responses were to be reassessed by the system and that 80% of the final grade for each student was based on the system-generated score for the student's answers with 20% based on the system-generated score of the student's peer assessment responses. In contrast, Group 1 participants were not given this information. This manipulation was intended to produce contrasts in thinking, and assessment attitudes among the students in the two groups. The students also received guidance on answering the questions, on assessing peer responses and on using the peer assessment system. Each student had to answer the open-ended questions according to the scoring criteria.

Findings and Evaluations

System-Generated Assessment of Student Answers (System score1)

Assessment is a vital part of an educational process. Time spent for assessing students is time that is no longer spent instructing them. Administration and processing of students' assessments impose a large toll on the instructor's time (Klein, Kyrilov, & Tokman, 2011). To minimize the time and effort required of the teacher for assessment, the system automatically scores free-text answers written by each student.

Table 4 illustrates the results of the system-generated scores for the answers from Group 1 and Group 2 participants, respectively. As shown in the Table 4, the scores for each student in both

Table 4. The System score1 representing system-generated scores for student answers of the two groups on five questions

Group	N	Question1		Question2		Question3		Question4		Question5	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	20	2.79	0.56	3.81	0.96	4.79	1.14	4.77	0.79	7.48	1.83
2	20	2.94	0.58	4.10	0.47	4.71	0.92	5.50	0.98	8.56	0.83

Mean is an average of System score1 for students in each group; SD = Standard Deviation; N is number of students.

groups improved significantly across the five assessment questions. Thus, in the process of answering questions, assessing one another and receiving feedback from peers, students gained more knowledge and produced increasingly accurate answers over the course. This finding can be clearly seen in Table 8.

System-Generated Assessment of Peer Assessment Responses (System score2)

Assessment is an important part of an educational process. It not only supports for grading learners, but also encourages learners in their learning. The assessment of learning is an assessment for learning (Tillema et al., 2011). Moreover, Peer assessment gives students a sense of ownership over the assessment process, fosters their motivation, improves learning, and turns assessment into a part of the learning process (Tillema et al., 2011). Through peer assessment, students can identify their strengths and weaknesses in their learning, improve their self-assessment ability, and engage in deep and meaningful learning.

To calculate System score2, we obtained one thousand peer assessment responses in total to all questions, and the system evaluated these results and assigned scores for every student. Table 5 presents System score2 for the two groups. Each student score was the average System score2 for each question given that each student assessed the answers of five other students and thus scored five times on System score2. The Mean values in Table 5 presents the average score for each question across all participants. Based on the comparison results in Table 6, we could observe that System score2 for Group 2 participants were, on average, greater than that of Group 1 participants. This finding indicated that Group 2 participants were more accurate than Group 1 participants in assessing their peers' answers. The comparison results in Figure 5 and Table 6 also revealed significant improvements in the quality of peer assessment among Group 2 participants. They had positive attitudes toward the assessment method and the way in which the final score was calculated. The finding strongly suggested that the proposed method of peer assessment was an appropriate system for helping students practice their assessment skills and learn new concepts.

Table 5. Mean System score2 (system-generated scores of peer assessment responses) for students of the two groups on the five questions

Group	N	Question1		Question2		Question3		Question4		Question5	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
1	20	5.83	0.97	6.35	1.13	7.82	0.67	7.39	0.74	6.98	1.10
2	20	6.08	0.76	6.72	1.24	7.49	0.86	8.10	0.76	7.93	0.71

Table 6. Comparison of System score2 between Groups 1 and 2

Group	Question1	Question2	Question3	Question4	Question5
1	5.83	6.35	7.82	7.39	6.98
2	6.08	6.72	7.49	8.1	7.93
Comparison	+.25	+.37	-.33	+.71	+.95

The Final Score

In education, assessment has many targets and one of most important goals is to grade learners based on assessment results. Hence, the evaluation results point out the achieved knowledge of learners during learning period, and also dominate learning activities. Therefore, this study considered all assessment aspects for calculating the final student score. These assessment aspects were based on system-generated assessment of student answers and system-generated assessment of peer assessment responses. The final score for each student was calculated, and the averages of final scores for students in two groups were calculated and presented in Table 7. The IBM SPSS statistics software was performed to determine significant difference, effect size and the improvement in the final scores across all students on some questions. Scores across each pair of consecutive questions improved significantly (see Table 8).

Figure 5. Mean System score2 for Group 1 and 2 participants on the five questions

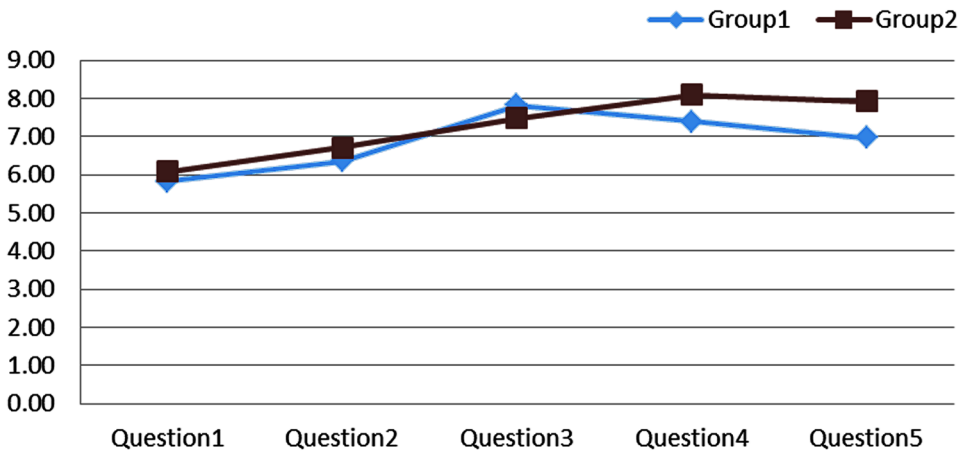


Table 7. The final scores of students in the two groups on the five questions

Group	N	Question1		Question2		Question3		Question4		Question5	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
1	20	3.40	0.56	3.98	0.63	5.39	0.89	5.29	0.60	7.38	1.57
2	20	3.57	0.59	4.62	0.43	5.26	0.65	6.02	0.74	8.43	0.72

Table 8. Score improvement on the five questions for all students collapsed across groups (n=40)

	Question1 (1)	Question2 (2)	Question3 (3)	Question4 (4)	Question5 (5)
Mean	3.48	4.30	5.33	5.66	7.91
SD	.557	.61	.75	.75	1.23
Pair test	(2)>(1) (t= -5.620*, r=.67)	(3)>(2) (t= -5.998*, r=.69)	(4)>(3) (t= -1.807**, r=.28)	(5)>(4) (t= -9.108*, r=.82)	

*p< 0.001; ** p< 0.1; r: Effect Size

This set of findings demonstrated significant improvement in both learning outcomes and peer assessment skills in both groups through assessment questions, in line with the results of (Liang & Tsai, 2010; Tsai & Liang, 2009). Overall, our findings shown that the proposed system of peer assessment had an active influence on peer assessment activities and the quality of peer assessment.

Finally, Table 9 shows statistically significant differences between students in the two groups, with the scores of Group 2 students exceeding the scores of Group 1 students by 4.9%, as illustrated in Figure 6, and the statistics with significant difference $t(19)= -5.653, p< 0.001, r= .79$. Hence, the proposed method actively affected and enhanced learning and peer assessment in online learning environments. In proposed method, peer assessment activities were not influenced by assessee scores, which directly influence assessors' study results. As Group 2 students were aware of this information, they exerted greater care in observing their peers' responses and assessing their peers' answers and, ultimately, experienced greater improvement in both their learning and assessment skills.

Table 9. Comparison across students' final scores between the two groups (n=40)

	Mean	SD	Pair test
Group 1	5.09	0.23	(t= -5.653, p< 0.001, r= 0.79)
Group 2	5.58	0.30	
Comparison	+.49		

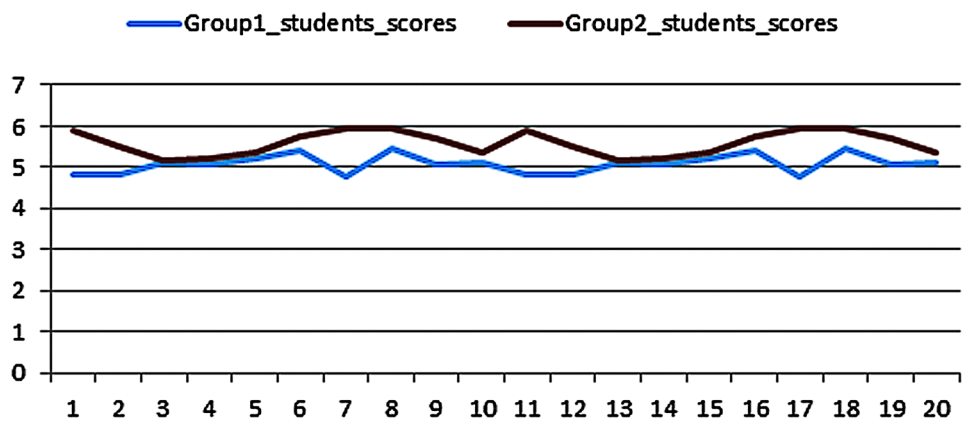
DISCUSSION AND CONCLUSION

Discussion of the Results

The research questions that guided this study included (a) How do assessment techniques can be used to make students have positive attitudes and perceptions, and foster full effort among students engaging assessment in E-learning environments? (b) How can organize algorithm for evaluating students' based on multidimensional assessment to encourage students' activities and collaborations? and (c) How do students improve their learning results through the proposed assessment method?

In online learning environments, the teacher or instructor is unable to observe or conduct peer assessment activities. As revealed in (Topping 2010; Strijbos 2010), students hesitate when they downgrade or criticize their peers, the likelihood that peer assessment will be occasionally unreliable and unfair and students assess for form's sake. In light of this constraint, it is important to

Figure 6. The comparison of the average of the final score of five questions for each student in two groups



develop assessment techniques that encourage positive attitudes and full effort on the part of students in online learning environments. Hence, the assessment techniques in this study focus on evaluating the accuracy of peer assessment, which is integrated into the final score for each student. Because peer assessment activities are evaluated and acknowledged by the assessment method, so students are responsible for their peer assessment activities. The peer assessment result only affects the assessor grading result, so it makes student has positive attitudes and perceptions. If students have great effort in their peer assessment activities, they will get higher score than others who lack effort. The assessment technique, therefore, fosters full effort among students engaging assessment in E-learning environments.

Following the assessment results that find out the answer of the research questions. Table 5 presents the results of the system assessing peer assessment responses (System score2) for two groups. The Mean values in Table 5 present the average score for each question across all participants. Based on the comparison results in Table 6, this study can conclude that System score2 for Group 2 participants are, on average, greater than that of Group 1 participants. This finding indicates that Group 2 participants are more accurate than Group 1 participants in assessing their peers' answers, suggesting that the diverse factors of attitudes and perceptions may play a role in peer assessment. Given that every student spends a considerable amount of time on answering questions, assessing their peers and receiving peer feedback for each question, students gain in more knowledge and assessment skills across the course of the some questions. The comparison results in Figure 5 and Table 6 also reveal significant improvements in the quality of peer assessment among Group 2 participants. This results lead to the corollary of perceptions that, the students in this group have positive attitudes toward the assessment method and the way in which the final score is calculated. It is namely the answer of the first research question.

Assessment and peer assessment are activities that can enhance students' collaborations and activities. Currently, the assessment of learners in conventional E-learning systems is only one dimension in which learners are required to produce answers, for example, by selecting multiple-choice, true/false, or matching answers or by giving short answers. This type of assessment still lacks interactions among the learners, and thus, it may not fully support learning. Many researchers have endeavored to propose an open-ended question method for evaluation, but their methods still focus on content assessment rather than learners' activities, which again lack interactions among the learners. This study concentrated on creating a new assessment method using open-ended questions with the aim of enhancing collaborations, activities and interactions of learners. In this study, a process model with M-DA and an algorithm for evaluating learners based on the M-DA were proposed for enabling effective learning and encouraging learners' activities.

Multidimensional assessment was described by Figure 3, the conceptual framework of M-DA for free-text answers could work under organization of the algorithm of M-DA. The second research question, therefore, can be solved.

Peer assessment practices have been developed and applied across multiple areas with different characteristics. Throughout this study, there is significant improvement in system-generated scores of student answers in two groups across the assessment questions. In Table 5, the system-generated scores for peer assessment demonstrate that the knowledge and assessment skills of students improve and become increasingly accurate over the course of the questions. This finding aligns with the results of previous studies e.g., (Liang & Tsai, 2010; Tsai & Liang, 2009). The

comparison results in Table 6 also revealed that the majority of the average scores for each question in Group 2 exceed the corresponding score in Group 1. This finding indicates that, compare with Group 1 students; Group 2 students give more accurate assessments of their peers' answers. The assessment results of Group 2 students are also improved significantly by the assessment method and the way in which the final score is calculated. The final results in Table 7 shows that the mean scores of Group 2 students significantly exceed the mean scores of Group 1 students. The average scores of Group 2 students increased by 4.9% in comparison with the scores of Group 1 students, and the statistics with significant difference $t(19)= -5.653$, $p< 0.001$, $r= .79$ as shown in Table 9.

Discussions in (Chen, 2010; Kaufman & Schunn, 2011; Papinczak et al., 2007; Topping, 2010) converge on the observation that, at times, peer assessment can be unreliable and unfair, with a few students holding negative attitudes, giving only perfunctory assessment and not paying attention to peer answers in online peer assessment systems. These observations coincide with the comparison between two groups in this study given that, in previous methods, the results of peer assessments tended to be factored into the final score of students being assessed. However, in the proposed method, peer assessments are not integrated into the final score of the students being assessed. Instead, the system generates a score of the accuracy of peer assessment responses and this score is integrated into the final score for every student. Because the results of peer assessment impact the score of the assessor only, students become more active in peer assessment activities. If students pay attention on their peer assessment activities, they will get the final score better than the others less attention. Thus, the proposed method helps students overcome their negative attitudes toward assessment and prevents unfair assessment in an online peer assessment system. These achievement results are also the answer of the third research question.

Conclusion and Future Research

This study describes a novel method of implementing peer assessment with multidimensional approach in online learning environments to enhance learning efficiency of activities and collaborations in E-learning environments. In this study, the uses of assessment techniques were examined to encourage students to develop positive attitudes toward assessment, to produce fair assessment and to engage peer assessment in their full effort in online learning environments.

Moreover, this research proposed a multidimensional assessment method that uses the M-DA system to assess free-text answers to enhance the efficiency of assessment activities. This approach enables interactions and collaborations in E-learning environments. The M-DA method aims to assess students based on two criteria, i.e., the students' knowledge comprehension and activities. Students can answer the teacher's questions according to answer criteria. Each student is allowed to assess other peers' answers by giving scores and comments. The M-DA system can evaluate the comprehension level of each student based on assessing student answer and peer assessment responses. The M-DA approach not only encourages student to assess actively but also provides student with the opportunities to gain more knowledge from the comments of others through the assessment activities.

The proposed method includes three sub-assessment approaches. After each student answers a question, the system assesses the student answer, followed by student assessment of their peers' answers. Finally, the system scores the peer assessment responses.

To evaluate the proposed method, this study implemented the assessment method on two groups of students in a real course. The comparison results in Table 6 also revealed that the majority of the average scores for each question in Group

2 exceeded the corresponding score in Group 1. This finding indicates that, compared with Group 1 students, Group 2 students gave more accurate assessments of their peers' answers. The assessment results of Group 2 students also improved significantly through the assessment method and the way in which the final score was calculated. The final results in Tables 7 show that the mean scores of Group 2 students significantly exceeded the mean scores of Group 1 students. The average scores of Group 2 students increased by 4.9% in comparison with the scores of Group 1 students, the statistics with significant difference $t(19)= -5.653$, $p< 0.001$, $r= .79$ as shown in Table 9. Hence, the proposed method can enhance the quality of peer assessment in E-learning environment.

In light of the findings, the proposed assessment method is a promising method that can be used to promote the development and improvement of learning and the quality of peer assessment among students. Furthermore, the findings point out that the attitudes and perceptions involved in peer assessment in online learning environments. Nevertheless, in this study, the assessment results may be dominated by many factors, e.g., separated students into two groups or the difficulty level of the open-ended questions. However, throughout the finding, peer assessment results were significant improvement. It can thus be suggested that assessment approach should consider the evaluation and acknowledgement for the quality of peer assessment activities in online peer assessment system. This study gives a new peer assessment approach and it is applicable to the real world to assess student in online learning environments. There are still areas for development in peer assessment method, such as the capacity for self-supervision, and the need for improvement in assessment accuracy by integrating new technique for assessing open-ended question into multidimensional assessment method. These aspects will be the next foci of our future research.

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KEY TERMS AND DEFINITIONS

E-Learning: Is the use of electronic educational technology in learning and teaching.

E-Learning Collaboration: Is collaboration in E-learning environment.

Multidimensional Assessment: Is combined three dimensions of assessments (system assessment of students' free-text answers, peer assessment of students' free-text answers and system assessment of the peer assessment).

Open-Ended Questions: Are unstructured question in which possible answers are not suggested, and the respondent answers it in his or her own words. Such questions usually begin with a how, what, when, where, and why and provide qualitative instead of quantitative information. Open ended questions are asked generally during exploratory research and where statistical validity is not a prime objective.

Peer Assessment: Is a process whereby students or their peers grade assignments or tests based on a teacher's benchmarks. The practice is employed to save teachers time and improve students' understanding of course materials as well as improve their metacognitive skills.

Scoring Open-Ended Response: is an evaluation for open-ended response by score.

Vector Space Model: Is an algebraic model for representing text documents (and any objects, in general) as vectors of identifiers, such as, for example, index terms. It is used in information filtering, information retrieval, indexing and relevancy rankings.

ENDNOTES

1 http://grepcode.com/snapshot/repo1.maven.org/maven2/gov.sandia.foundry/porter-stemmer/1.4

2 http://wordnet.princeton.edu/

3 http://en.wikipedia.org/wiki/Vector_space_model

Chapter 14
Designing an E-Learning Curriculum

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ABSTRACT

In this chapter, the authors propose to look at the empirical findings that will be useful for instructors, who wish to improve their understanding on how to design an e-learning curriculum that will take into account the different learning needs of their engineering students. The studies surveyed in this chapter will focus on gender and game-based learning, which will offer insights as to how to improve the level of participation and learning outcomes for females in male-dominated fields. In particular, the authors will focus on gender issues and how learning in an e-learning curriculum can be designed to engage female students and to improve retention of female students. The authors propose the following change in an engineering e-learning curriculum: mixed-sex groups, use of collaborative activities, blended learning, and communication tools, and mixed-sex curriculum design team.

INTRODUCTION

The purpose of this chapter is to offer ways of designing an e-learning curriculum so that it engages students, both female and male, and leads to an increase in the level of participation and motivation towards engineering among female students. If more female students move into industry to become practicing engineers and scientists, society will ultimately benefit more from innovations in products that have been designed by a more equally balanced inclusive team composed of male and female members, rather than by a team of male members alone. Indeed, Wuchty, Jones, and Uzzi (2007) have argued that most important scientific innovations have been produced by collaborating teams, and Woolley, Chabris, Pentland, Hashmi, and Malone (2010) have argued that the presence

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of females in a team greatly improves team collaboration. Hence, having female members helps team collaboration which in turn results in greater scientific innovation and discovery. In order to have inclusive engineering teams in the workplace, there must be enough female qualified engineers. However, currently female engineering graduates are outnumbered by their male counterparts. To attract more females into engineering and to retain females who minor or major in engineering, the authors propose that the engineering curriculum should be redesigned to engage female students.

In this chapter, the authors will look at empirical findings that will be useful for instructors, students, and professionals who wish to improve their understanding of how to design an e-learning curriculum that takes into account the learning needs of their students. The studies surveyed in this chapter focus on gender as well as game-based learning, which offer insights into how to improve the level of participation and learning outcomes for females in male-dominated fields. In particular, the authors will focus on gender issues and how learning in an e-learning curriculum can be designed to minimize gender differences in learning outcomes and raise the levels of participation of female engineering students.

BACKGROUND

Stoilescu and McDougall (2011) highlighted the presence of the gender digital divide in computer science undergraduate programs in Canada. They found that the female undergraduate students were not lacking computer resources, but what was lacking was equity in instruction with computers and opportunities to participate in the computer culture. The latter two issues gave rise to the female students' high anxiety levels, low confidence, and ultimate underachievement. These female students needed to have more valuable experiences in the field. Stoilescu and McDougall (2011) proposed giving them more opportunities to access the computer culture in formal and informal settings. One way of improving opportunities in informal education was to allow female students to have more opportunities to practice writing code.

The current level of participation in engineering education by women is low compared to that of men. Schiebinger and Schraudner (2011) argued that although much had been done to try to achieve gender equality in educational institutions, there was the need for "gendered innovations in scientific knowledge and technology design" (p. 157). They argued that a gender analysis must be present as a control from the beginning of a project to ensure rigor in science, engineering, and medicine research, policy, and practice. In the design of an e-learning curriculum, as Schiebinger and Schraudner (2011) have pointed out, it is paramount that a checklist be created that helps technology designers to identify key gender components for operationalizing sex and gender analyses for designers. Some components suggested in the article can be applied in the design of an e-learning curriculum. These are rethinking language and visual representation, rethinking stereotypes, analyzing academic disciplines, redefining key concepts, and rethinking theory.

Game-based learning is an emerging pedagogical paradigm that could represent an alternative approach to achieving both the goals of developing engineering practices and gender equality in engineering education. This is because games allow students to experience what practicing engineers do in the real world and to take on the identity of an engineer. Regarding commercial games with affordances for players to develop social identities, Squire (2006) saw games as sites where learning could be looked at both as "(a) interaction in the social and material world, where learners participate in open and closed problem solving; and (b) participation in distributed social organizations such as self-organizing learning communities" (p. 22). To add, Jan (2013) distinguished between games as "technological innovation" and "pedagogical innovation." Observing that commercial

games with affordances for 21st century learning, such as those studied by Squire (2006), often fail to take off in the classroom, Jan (2013) proposed the latter conception to envision the classroom as being gamified so that games are modes of learning for 21st century education.

Based on games as modes of learning, the authors propose that, firstly, the goal of an e-learning curriculum design is to create learning experiences that allow engineering students to begin to participate in the kinds of practices that are required of engineers in the future. For instance, these engineering practices are reflected in the scope of work identified by the School of Engineering of the National University of Singapore include, "engineers innovate and create all kinds of functional systems, products and services for modern living by applying a combination of mathematical, scientific and engineering fundamentals" and they "oversee and manage teams of technical and non-technical personnel" (National University of Singapore, 2015). James Gee (2005) identified principles of game-based learning, and some of these principles potentially make for the kinds of educational experiences that prepare engineering students for their future work. For instance, good video games operate by the principle of "identity," based on his view that "learning a new domain, whether it be physics or furniture making, requires the learner to take on a new identity: to make a commitment to see and value work and the world in the ways in which good physicists or good furniture makers do" (Gee, 2005, p. 4). Secondly, the authors propose that the goal of an e-learning curriculum design is to enable students of engineering, regardless of gender, to level up in the acquisition of requisite engineering practices. This is consistent with Gee's principle of "performance before competence" (Gee, 2005, p. 13). In this view, players can perform before they are competent, supported by the design of the game, the smart tools the game offers, and often, too, the support of other, more advanced players.

Curriculum Design

To improve the level of participation and learning outcomes of females in male-dominated fields such as engineering, there is the need to go back to the drawing board, that is, the planning of the curriculum. According to Deng (2010), "curriculum planning refers to the decision-making process concerning the substance of schooling, that is, the knowledge, skills, and dispositions that constitute the experience and outcomes of schooling" (p. 384). Deng (2010) referred to Doyle's (1992a, 1992b) view of the curriculum as operating across three levels: institutional, programmatic, and classroom. In the area of engineering in higher education, there is consensus that gender equity is desirable, a goal reflecting the ideals and expectations shared in today's society. Therefore, the authors will be focusing instead on programmatic and classroom curriculum planning, as curriculum planning at the institutional level involves discourse on curriculum policy at the intersection of society, culture, and schooling. That is, in higher education, it is unlikely that there is a national curriculum planning body governing engineering education across universities.

Programmatic curriculum planning focuses on "curriculum writing in the form of curriculum documents and materials" (Deng, 2010, p. 384). It seeks to rationalize how the knowledge, skills, and dispositions set out at the institutional level are translated into the individual courses taught by instructors. That is, it seeks to operationalize what is in the institutional curriculum. Here, the main objectives of engineering programmes can be set out to take into account the needs of female students so that gender equity can be achieved in engineering education. Deng (2010, p. 385) referred to Tyler (1949) who believed that curriculum should address the questions concerning purposes, content, and organization:

1. What educational purposes should the school seek to attain?

2. What educational experiences can be provided that are likely to attain these purposes?
3. How can these educational experiences be effectively organized?
4. How can we determine whether these purposes are being attained?

With regard to the third level of curriculum planning, Deng (2010) understood the enacted curriculum as being characterized by a cluster of events jointly constituted by the moment-by-moment interactions among the teacher and students in the classroom. It involves transforming the institutional and programmatic curriculum embodied in curriculum documents into experiences that cater to the experiences, interests, and abilities in a particular classroom. In this chapter, it has been noted that the curriculum has not been translated into positive experiences for the less dominant groups such as women. Thus, it is timely that the engineering curriculum be changed to reflect the needs of these less dominant groups.

Insights from Studies in Game-Based Learning

Game-based learning is an emerging learning paradigm that could offer insights into achieving gender equity in engineering education that would impact engineering practices in industry. For example, one important principle of game-based learning is the principle of identity (Gee, 2005). If the female engineering student were to take on the identity of an engineer in one of some of the e-learning activities offered by the engineering curriculum, that might motivate her to become a practicing engineer as she becomes more comfortable with succeeding in that role. Instead of imagining what being an engineer would be like, she could explore the role of a practicing engineer safely within a university context. Shaffer, Squire, Halveson, and Gee (2005) argued that video games were powerful contexts for learning because students who inhabited and acted in such worlds could develop situated understandings, powerful identities, shared values, and ways of thinking in the particular community of practice. Thus, female engineering students could be brought into the epistemic frame as they thought and acted like engineers.

To build such games requires understanding how practitioners develop their ways of thinking and acting. Such understanding is uncovered through epistemographies of practice: detailed ethnographic studies of how the epistemic frame of a community of practice is developed by new members. That is more work than is currently invested in most "educational" video games. But the payoff is that such work can become the basis for an alternative educational model. Video games based on the training of socially valued practitioners let us begin to build an educational system in which students learn to work (and thus to think) as doctors, lawyers, architects, engineers, journalists, and other important members of the community—not in order to train for these pursuits in the traditional sense of vocational education, but rather because developing those epistemic frames provides students with an opportunity to see the world in a variety of ways that are fundamentally grounded in meaningful activity and well aligned with the core skills, habits, and understandings of a postindustrial society. (Schaffer, Squire, Halverson, & Gee, 2005, p. 8)

What we can glean from the quotation above is the power of having students learn the core skills, habits, and understandings of each profession so that they can experience being an engineer or an architect while they are still in school or university. This sense of identity will help in the retention and achievement of female students in engineering.

Studies have shown that there are gender differences in the level of general participation in gaming. Indeed, prior research has found that

males spent more time playing computer games than females (Bertozzi & Lee, 2007; Buchman & Funk, 1996; Chou & Tsai, 2007; Colwell & Payne, 2000; Green & McNeese, 2008; Lucas & Sherry, 2004; Solomonidou & Mitsaki, 2009; Winn & Heeter, 2009). Males had traditionally more access to public leisure spaces such as video arcades, bars, and pubs (Dickey, 2006; Griffiths, 1991), and domestic spaces such as computers and television sets in the living room (Dickey, 2006; Facer, Furlog, Furlog, & Sutherland, 2001; Schott & Horrell, 2000).

These gender differences in the level of general participation in gaming have raised concerns that it may translate into gender differences in learning when game-based learning is introduced in schools. Jenson and de Castell (2010) pointed out that early work on gender and game play came about as a result of an initial concern for the low numbers of women and girls in the field of computing. Cassell and Jenkins (1998) theorized that if girls and women were to develop skills and interest in playing video games, more of them might be prompted into entering the world of computing. In addition, Jenson and de Castell (2011) have also remarked that there were gendered patterns of technology access, interest, and competence. They argued that boys' early and sustained exposure put them at an advantage with respect to computer competence and confidence when they entered schooling. Moreover, the game content of video games in the market also caters more for males than females (Lucas & Sherry, 2004). Thus, with the advent of the use of computer games for learning in schools, girls may be disadvantaged.

Therefore, there is an urgent need for educationally-based research to investigate gendered patterns of game play in schools as a way to inform more equal participation and learning for both boys and girls. In her investigation of the learning effectiveness of an educational computer game for learning computer memory concepts among 88 16- to 17-year-old students in two Greek high schools, Papasterigou (2009) found that there were no significant differences in learning gains between boys and girls despite boys' prior greater involvement and experience with computer gaming. However, since the students in her study played the computer game during specific lesson time slots, both boys and girls spent similar quantities of game play time. She did not investigate whether there were gender differences in game play time if students could decide their level of participation, something that a mobile game played outside of class might afford. Consequently, her study could not inform how games might be designed for a more level playing field. If there is a significant gender difference in the level of participation, a game-based learning approach may lead to inequalities in learning.

Jensen and de Castell (2011), in a three-year study of 60 girls and 44 boys in the greater Toronto area, found that girls had limited access to console games at home. It was only in the second year where the girls in the gaming club had access to a female research assistant who was a gamer that they proceeded to play more complex games as this assistant helped them navigate the general control mechanism of the game, and menus as well as the purposes and rules of games. Jensen and de Castell (2011) noted this shift in game play practices, which came about as a result of their interaction with an experienced female gamer. In the same vein, to retain female engineering students, help from female teaching assistants who have expertise in the subject area may be useful for these students.

Gwee, Tan, and Jan (2014) found that girls in mixed-sex teams in a mobile game-based learning curriculum spent more time in game play than girls in single-sex teams. In an interview with a girl from a mixed-sex team, the girl pointed out that the boy in her team who became the informal leader provided strategies on how to win the game. Therefore, having mixed-sex groupings may help females to be more engaged in game play as they are able to get help from males who are more skilled in digital game play. Similarly, in designing

an e-learning curriculum, educators can plan for mixed-sex groups to help females become more engaged in their learning.

Gwee, Tan, and Jan (2014) also found that the change in the goals and design of the *Statecraft X* social studies game also led to higher levels of participation in females. The changes included (a) the positioning of the game where the winning team was the one that had the highest composite score of average happiness of citizens in a faction, economic total (profit), and population levels in the towns under their charge, (b) the encouragement of the use of diplomacy instead of force to take over towns, and (c) the team members having to share the same pot of money. The results indicated that as a result of the changes in the design of the game-based curriculum, girls in the second intervention showed higher levels of participation than girls in the first intervention. Gwee, Tan, and Jan (2014) raised the possibility that females might have preferred the more collaborative nature of the revamped game-based curriculum or that the males had to teach the females how to play the game as the team's results were at stake.

Given the similarities between the experiences of females in a game-based learning curriculum and those of females in male-dominated fields such as engineering, the cited research in this chapter offers possibilities on how to design e-learning curricula so as to encourage higher levels of participation for girls in male-dominated fields. The e-learning curriculum should be designed to offer structures and scaffolds that help girls to level up.

PROPOSED CHANGES IN ENGINEERING E-LEARNING CURRICULUM

Use of Simulation

For the orientation of female engineering students entering university or to get female middle or high school students interested in an engineering career, simulation games such as *Digital Zoo* and *Nephrotex* might help bridge the gap for these students who are deciding whether they should choose engineering as a major or career. Internships in engineering firms can help students to experience first-hand the practices of practicing engineers. However, as Arastopour, Chesler, and Shaffer (2014) pointed out, typically, engineering students did not have the opportunity to take part in internships until they were further along in their course, and, by then, first-year female engineering students, whose levels of confidence tended to fall, had dropped out of the course at the end of their freshman engineering classes. They therefore suggested that using simulation games in the freshman engineering classes might help women to become more confident about becoming engineers and persisting in this course of study.

Indeed, in a study of 45 engineering students of which 12 were women, Chesler, Arastoopour, D'Angelo, Bagley, and Shaffer (2013) found that students were engaged and motivated after having taken an engineering course module that used the same virtual internship game, *Nephrotex,* which simulated engineering professional practice. Considering *engineering design* to be an important authentic professional practice in engineering education, Chesler et al. (2013) incorporated aspects of engineering design such as considering alternatives, iteration, making and justifying decisions, team work, communication with teammates, supervisors, and clients in a computer-simulated environment which became a virtual professional practicum (Chesler et al., 2013) into *Nephrotex*.

The game of *Nephrotex* simulates the experience of engineering students who are interns at a fictitious company *Nephrotex*. The game was initially designed, developed, and tested by the faculty, graduate students, and undergraduates of the University of Wisconsin-Madison College of Engineering and the School of Education, and it was offered as an elective module in a first-year engineering course. The students were assessed

on the extent to which they were able to design and solve problems in ways similar to a professional engineer using a new assessment tool, Epistemic Network Analysis that was developed to measure complex thinking and student learning in these simulated situations. Complex thinking was defined as the understanding of how different parts of problem solving are linked. For example, the players have to think about which values to consider before taking an action in the game and to think about the knowledge that he or she needs to gather before making different decisions. This new assessment tool not only measures the learning outcomes of the game, but also the learning process, so that engineering faculty are able to ascertain the extent to which engineering students are learning to think and act like practicing engineers.

In a later study using the same game *Nephrotex,* Arastoopour, Chesler, and Shaffer (2014) suggested that having video games that simulate internships during first-year engineering classes might help stem the tide of departing female engineering students. They set up an experiment with an experimental group of 138 students who played the internship simulation game, *Nephrotex,* and a control group of 95 students who took the traditional introductory engineering course in two large American public universities. The results of the study indicated that women in the experimental group had a statistically significant increase in confidence and commitment to the engineering field after the intervention compared to women in the control group. There was no difference between male students in the experimental and control groups. Arastoopour et al. (2014) felt that men who chose engineering started out more confident and committed and hence did not experience a significant change as a result of the intervention. It was also found that positive changes in commitment and confidence for both men and women were associated with activities in engineering design in the simulation. It was noted that the more students made connections between engineering design and other engineering epistemic elements, the more likely students felt confident and committed to engineering.

An advantage of simulation games is that students get the opportunity to practice being engineers in a safe environment and to determine whether the actions that they carry out in the games are similar to those of professionals. Nash and Shaffer (2013) described how this was being done with the Epistemic Assessment Tool (ENA) that quantifies thinking in the course of action.

We operationalize such a question by comparing the ''distance'' between a mentor's frame and the learners' collective frame when they have meetings together across the time of the practicum. By distance, we mean the projection of the structure of the epistemic frame, as quantified by ENA, into a high dimensional space. Using multi-dimensional scaling, we can visualize epistemic trajectories: models that show the distances between team and mentor's frames throughout the practicum change over time. Finally, constructs borrowed from social network analysis can help us interpret these trajectories. For example, the relative centrality of a frame element quantifies the extent to which it is connected to other elements in the professional discourse, and therefore can help us interpret the mathematical concept of "distance" by suggesting in what ways two different frames are similar or different. (p. 755)

Composition of Groups

Having mixed-sex groupings in the *Statecraft X* game was shown to be helpful for girls learning to be governors in that educational game (Gwee, Tan, & Jan, 2014). Girls in mixed-sex teams in this mobile game-based learning curriculum were found to have spent more time in game play than girls in single-sex teams. Girls in the mixed-sex team also seemed to have benefited from the gaming expertise of the male members who taught them game strategies.

Having mixed-sex groupings not only increases the level of participation of females, it also contributes to better team performance, For example, Woolly and her colleagues (2010) found that the proportion of women in a group also contributed to the measured collective intelligence of the group because women were better able to pay attention and interpret non-verbal expressions of group members and there was more participation of group members in the sense that each was able to take turns to contribute to group discussions. That is, if fewer people dominated the discussion and there was a more equal distribution of turns in the conversation, then the collective intelligence of the group was higher. The collective intelligence of the group increased with the proportion of females in the group. The researchers noted that the effects of gender diversity were largely mediated by the social sensitivity of the group members and that women had higher measures of social sensitivity than men.

Bear and Woolley (2011) looked at research on gender and the influence of people in groups and found that men's and women's influence on each other was almost equal in groups where the composition was balanced between men and women. They noted that members of heterogeneous groups reported feelings of higher levels of self-efficacy and morale than those of homogenous groups. They also reported that in a group of one woman and two men compared to a group of one man and two women, the solo women talked less than women in the majority. Interestingly, the opposite was the case for men. Solo men were more talkative than men in the majority. The results of Ingram and Parker (2002) were similar in that the solo woman in an engineering team was found to be tentative and accommodating in many of their interactions with their male teammates, showing a lack of confidence in their technical knowledge, while the latter were aggressive in their display of technical knowledge, and made sexually explicit and demeaning jokes. Ingram and Parker (2002) proposed that two or more women should be present in a team. They proposed that "instructors in traditionally male-dominated faculties such as engineering may choose to reconsider the manner in which teams are selected in order to maximize the interactional contributions of women and minimize the risks of their feeling uncomfortable or less confident" (p. 109).

In professions like engineering that are dominated by men and where teams are dominated by men, gender diversity had a strong negative effect on team performance whereas in gender-balanced professions, gender diversity had significantly positive effects on team performance in terms of objective outcomes such as the quality of the product and financial outcomes, and subjective outcomes in terms of supervisor rating and self-rating (Joshi & Roh, 2009). Bear and Woolley (2011) suggested that the integration of women in male-dominated fields might initially be difficult but should improve as their representation in the team moves towards parity. Indeed, Frink et al. (2003) noted that organizations in male-dominated fields found it difficult to capitalize on the benefits that females brought to a team although perfect gender balance in an organization led to optimal market performance. It should be noted that when there was gender imbalance in the team, the team's performance was affected negatively. Therefore, teams in workplace settings should strive for perfect gender balance in their teams to optimize the team's performance.

In the university context, one approach to the gender composition of groups is to ensure that there are equal numbers of males and females in mixed-sex groups and to ensure that females are not distributed as token members across groups as the latter arrangement has been shown to have a negative impact on the team's performance. Thus, for instance, there may be one or two mixed-sex teams and five all-males teams in an engineering classroom. Having gender diversity in teams will help improve the overall performance of the teams.

The instructor might also have to group students in different teams instead of having them

form teams themselves. Left to their own devices, the male and female students are unlikely to form teams that optimize gender balance. Indeed, in Jensen and de Castell's (2011) study, although the researchers had hoped to observe boys and girls playing video games together in the second year of the study, they found that boys and girls did not choose to play with one another until the third year of the study where the girls had leveled up in terms of their video game playing skills. Applying this to the e-learning curriculum for engineering students, instructors might consider grouping students to optimize gender balance in groups in the first two years of an engineering course.

In addition, there can be a buddy or mentor system where the more able students can help the less able ones. There could be groupings based on experience in e-learning environments so that girls or students with less prior experience can find their feet and gain confidence in an e-learning environment. This is consistent with previous research (Ingram & Parker, 2002), which also advocated a stronger representation of females in any mixed group so that the power relations do not disadvantage the females.

Collaboration

In Gwee, Tan, and Jan's (2014) work, they found that differences in game design in terms of collaboration resulted in a significantly higher level of participation in ninth-grade girls in the second intervention compared to those in the first. Interestingly, the level of participation between the two groups of boys did not change significantly. The important change in the game design was that in the second intervention, the team shared a common pool of money whereas in the first intervention, each person was given a sum of money to manage. This resulted in groups having to plan and strategize together. Similarly, teams in an engineering course could be awarded a common mark to ensure more collaboration among team members as they work together and to encourage team members to help one another to achieve the highest possible grade, thereby raising the participation level of female students.

In the same vein, Stump, Hilpert, Husman, Chung, and Kim (2011) found that out of 503 engineering students, female students ($n = 84$) reported using more collaborative strategies than male students in an informal collaborative context such as brief in-class peer discussion, study groups, and conversations after class when they were studying course content. They also found that middle performing male and female students reported seeking more collaborative learning opportunities than high or low performing students. They concluded that although the informal collaborative work did not result in statistically higher achievement, female students found collaborative work appealing and that it might help in the retention of female engineering students as well as with their academic achievement. They felt that supporting this need of affiliation with their course mates might help female students to achieve success in the engineering courses in the early semesters and that would in turn lead to higher levels of female student retention. In an e-learning curriculum, formal collaborative structures can be incorporated to support female students' need for affiliation and collaboration. Stump et al. (2011) also pointed out that supporting female engineering students in their need to collaborate might help them in their academic success and that this success had been linked to retention. Thus, designing for collaboration in an e-learning curriculum may be instrumental in the increase in academic achievement and retention of female engineering students. They have recommended changing institutional and instructional practices to support collaboration among students. These practices could include grading practices. They also suggested that collaborative activities might promote an atmosphere of friendliness and cooperation among students that might also help in the retention of female students in the engineering course.

Woolley et al. (2010) found that women helped collaborative teams produce better results because they were able to facilitate group work better due to better reading of the non-verbal behavior of their team members. They were also able to ensure that every team member was able to take a turn in team conversations so that team members could express their views and also respond to the views of others. Therefore, the collective intelligence of the group, defined as the group's performance in a wide variety of tasks was correlated with the proportion of females in the group, the average social sensitivity of the group, and the equality of distribution of conversational turn-taking. When a few people dominated a conversation, the collective intelligence of the group was lower than the group where group members had more equal turns in the conversation. Groups with more women seemed to be more responsive to each other in terms of turn-taking in conversations. Furthermore, groups with a higher proportion of women were found to display higher levels of social sensitivity as evidenced by the women's greater ability to read non-verbal cues and to infer what other group members might be feeling or thinking. Woolley et al. (2010) raised the question of whether better electronic collaboration tools might increase a group's collective intelligence as this intelligence appeared to depend on the way group members interacted with each other.

Expert and Peer Help

Based on Jensen and de Castell's (2011) study, it is paramount that in an e-learning curriculum, a mentor and helper be available for students who need help in navigating an e-learning platform. This finding is consistent with Huynh, Lee, and Schuldt's (2005) study where they advocated additional training for students who have less prior experience with technology for courses that require technology. This is to ensure that the students have the same level of expertise in technology. Indeed, Stoilescu and McDougall (2011) reported attrition rates for female university students studying computer science due to lack of expert help for writing code. Compared to male computer science students, the female students had less prior experience in writing code and needed more help because they had not built up a social network to help them when they ran into programming difficulties. Unfortunately, inadequate help was provided by the university instructors. As a result, the female students fell further behind as the course progressed in the term, and some left the course after the midterm test. Therefore, it may be useful to have help in technology prior to and during the e-learning engineering course for female students and those who have less prior experience using technology so that they are not disadvantaged learning about engineering content during the course.

It may also be useful for female engineering students to be part of a networked community of engineers who can help to motivate and encourage them throughout their course. This network may consist of practicing graduate engineers, both female and male, who serve as a resource for the questions they may have about engineering practices. Studies have shown that peer tutoring has a positive impact on learning in higher education. The aim of the study of Arco-Tirado, Fernandez-Martin, and Fernandez-Balboa (2011) was to determine the impact of a peer tutoring program among first-year students in civil engineering, economics, pharmacy, and chemical engineering. As part of their research design and procedures, the researchers used a range of experimental design methods and validated survey instruments for measuring study habits and social skills. They also implemented a structured peer tutoring program for the treatment group that consisted of a four-session seminar for tutors and 10 weekly sessions for tutees that focused on study skills (e.g., goal setting and self-assessment) and basic social skills. The results of this study showed statistically significant differences between the treatment and control groups, indicating that the

peer tutoring program had a positive impact on the tutees in terms of cognitive and meta-cognitive strategies. Interestingly, the program also had a positive impact on the tutors in terms of cognitive and metacognitive strategies as well as social skills (e.g., the ability to say "no"). Hence, the results suggest that the program resulted in an enhanced learning culture in addition to student success.

Alongside such studies that report positively on peer tutoring's impact on tutor learning, other studies attempt to understand how tutor learning occurs. In their review of peer tutoring, Roscoe and Chi (2007) proposed focusing on the processes of tutor learning in addition to outcomes and suggested the method of directly examining peer tutors' instructional and learning activities. They looked at the tutor learning activities of explaining and questioning for ways in which tutors might engage in "reflective knowledge building" processes or "knowledge-telling" processes (p. 541). With respect to both explaining and questioning, the review found that peer tutors relied most heavily on knowledge-telling explanations, even after extensive training in knowledge-building strategies. Hence, while it may be useful for female engineering students to be part of a networked learning community or community of practice where they can learn from other experts, there are key considerations, such as a well-structured program as well as tutoring or mentoring expertise, when it comes to making related forms of learning such as peer tutoring productive for both the expert and the learner.

Communication Tools

To support the collaboration and negotiation of meaning needed to solve complex engineering problems, communication tools such as online forums and chats can be used in complement with tools such as games. Indeed, the following studies, which have reported no significant gender differences in learning outcomes, include various forms of communication tools in their learning environments. Bruckman, Jensen, and Debonte (2002) found that girls spent significantly more time than boys communicating in the virtual environment and that programming achievement was correlated with prior programming experience, not gender. Similarly, Barab et al. (2007) reported that there was no gender difference in pre-test to post-test gains for their study using the *Quest Atlantis* game where girls were found to post twice as many chat messages as boys, to send more telegrams or abbreviated messages, and to post more messages than boys. These findings suggest an interesting proposition. While boys can be expected to be more readily initiated into a game-based learning curriculum, the use of appropriate communication tools can contribute to leveling up girls' learning with games given their greater propensity to learn collaboratively as suggested by findings such as those of Bruckman et al. (2002).

However, for such communication tools such as online forums, chats, and emails to realize their potential for learning, various considerations need to be taken into account. Joiner et al. (2011) studied the use of *Racing Academy*, a video game used to support undergraduate students' learning of mechanical engineering. They noted that while studies (e.g., Barab et al., 2007; Bruckman et al., 2002) have reported female students participating more in online chat than male students, participation in the online forum of their study was comparatively much lower. They suggested two possible reasons: (a) being on the same campus, students could already communicate face-to-face, and (b) there was little time for students to become familiar with the use of the Moodle-based forum. Therefore, when deciding how communication tools may be included in an e-learning curriculum, two considerations need to be factored in: (a) communication tools should complement, rather than substitute for, other established modes of communication; and (b) students may need to learn the basic communication functionalities of these tools before they use them for learning.

There are also some other issues that curriculum designers of an e-learning curriculum have to bear in mind while incorporating communication elements in the curriculum. Communication skills have been identified as an important component of engineering education. Riemer (2007) noted that the engineering industry required engineers to be effective communicators, especially in an increasingly globalized world. He identified three key challenges. Firstly, engineers needed to be sufficiently proficient in English as the proliferation of international projects requires engineers to communicate cross-culturally, and English being the "prime means of communication", was often used as it was the "global language between two people from different cultures where English was not the native tongue" (p. 89). Secondly, engineers were also expected to have regional communication skills. In an increasingly globalized world, Reimer argued, the prominence of English as an international language had been re-balanced so that "regional languages" such as Chinese and Arabic had become more important. Hence, engineers who used English as the primary mode of communication also needed to have some degree of proficiency in regional languages. Thirdly, Riemer noted that different professions had their own terminologies, citing examples in engineering such as *seaspeak* in maritime engineering, *airspeak* in aviation engineering and *railspeak* in railway engineering. Hence, engineers needed to be proficient in the use of profession-specific languages for communication.

Besides language proficiency, gendered perceptions of speech patterns also matter for everyday communication in the field of engineering. Wolfe and Powell (2009) noted that the culture of engineering was highly masculine. In engineering education, pedagogical approaches, such as collaborative learning, that were meant to promote active learning and to address the problem of high attrition rates of women actually resulted in experiences of gender bias. These experiences ranged from feelings of non-inclusion based on perceived differences in speech patterns to feelings of marginalization arising from overt expressions of sexism. In their study of 522 undergraduate students, Wolfe and Powell (2009) compared engineering and non-engineering students' perceptions of complaints more commonly spoken by men with those more commonly spoken by women. Their study revealed that masculinity of the engineering culture was manifested as gender bias against typical female speech in everyday interactions. These speech types included strategies such as self-effacement that were often intended by females to soften criticisms and are even recommended strategies for conflict management, but were seen by males as signs of weakness and being inefficacious.

Despite the increasingly complex demands on engineers to be effective communicators, "there is ample evidence that graduate engineers lack the required standard of communication skills, particularly when compared to the needs of the industry internationally" (Riemer, 2007. p. 89). Hence, communication should be a critical component of the engineering curriculum. Studies such as those of Riemer (2007) and Wolfe and Powell (2009) suggested a range of curricular foci. For Riemer (2007), these included

1. Oral communication skills, which are a key predictor of career success;
2. Listening skills, which entail the reception and comprehension of verbal communication;
3. Written communication skills, which involve the production of engineering text-types such as technical reports and peer reviews;
4. Visual communication skills and visual literacy, which require the production and comprehension of visual forms as modes of non-verbal communication; and
5. Emotional intelligence and communication skills, which are necessary for team-work.

In particular, empathy is a key quality in social communication for effective leadership and management, and showing empathy requires the effective use of both verbal and non-verbal cues.

Wolfe and Powell's (2009) study offers an additional perspective of the importance of emotional intelligence in social communication. In addition to studying perceptions of speech types in everyday communication, they also studied whether it was the gender or the type of speech of the speaker that influenced perceptions, with the resultant findings suggesting that it was the latter that influenced perceptions. Given that bias was not rooted in the speaker's gender, the implication of their study is that perceptions could be managed. Hence, Wolfe and Powell (2009) proposed some implications of their findings for engineering education. Women entering engineering education could moderate certain tendencies in their speech patterns, e.g., self-effacement strategies, which might signal weaknesses. Men studying engineering "should be coached to engage in fewer self-promotional and more modest speech acts" (Wolfe & Powell, p. 13). Echoing the key argument of our paper, Wolfe and Powell (2009) asserted that "if engineering educators could help coach students to reduce defensive self-posturing, they may not only create an environment more welcoming to women, but may also create a more collaborative environment where all students are more open to learning from one another" (p. 13).

Interestingly, Graesser, Keshtkar, and Li (2014) have looked into the research into the discourse patterns of tutors with students in an online environment and suggested that human or computer tutors might need to take into consideration the emotions of students when they were learning as evidenced by their online discourse patterns and respond to these emotions of frustration, boredom or confusion because these are emotions that might lead to student disengagement. For female engineering students, both human and computer tutors might have to take these into account as they interact with students online. For example, students might misunderstand the discourse function of certain speech act categories such as hints. Graesser et al. (2014) suggested that, to avoid having a confused student ask "what about that?" in response to a hint from a tutor, a good tutor would have minimized possible confusion by preceding the hint with a discourse marker that signaled that the tutor was going to give a hint. They suggested using discourse markers such as "Here's a hint" and "Let me get you back on track" before giving the content of the hint.

Therefore, it is important to consider very carefully the language used in online communication tools in the design of an e-learning curriculum to ensure that female engineering students do not feel marginalized during online interactions. Both male and female engineering students and tutors may need to adapt their language to help them communicate more effectively to each other and to create a more welcoming environment for female students. To keep female students engaged, tutors may consider using certain discourse markers to avoid confusion, frustration, or boredom.

Blended Learning

In Gwee, Chee, and Tan's (2011) study of 41 ninth-grade students learning governorship in a game-based learning curriculum in Singapore, they observed that classroom discussions and the reading of reflection blogs might have explained the result that there were no significant differences in learning outcomes despite the girls having reported playing the game *Statecraft X* significantly less often than the boys. In other words, although girls did not spend as much time playing the game as boys, that did not affect their learning because there were alternative modes of learning available in the game-based curriculum. Therefore, in the design of an e-learning curriculum for engineering students, curriculum designers may consider including elements of face-to-face learning activities such as classroom discussions that cater to the learning needs of female students.

There are studies that have shown no significant differences in online and blended learning. Masters and Oberprieler (2004) found no gender differences in online participation in a blended learning class. Students role-played characters in Human Rights and Health Rights disputes in small face-to-face groups before responding to questions posted online. It should be noted that no marks were given for these postings although tutors monitored them for formative assessment purposes. Masters and Oberprieler (2004) did not find any correlation between marks obtained in the initial IT skills test, and the number of postings or readings. It showed that the lack of computer skills prior to the class did not affect the students' ability to participate in online discussions.

On the other hand, there are other studies that have shown gender differences in online learning in favour of females. Price (2006) studied gender differences in a multi-disciplinary undergraduate course that had both non-online and online versions. For the online version, tutorial support was provided using computer-mediated conferencing and email support. For the non-online version, tutorial support was provided face-to-face with some email interactions. The total number of participants over three years was 1,991 students, with more women enrolling in the course than men. Price (2006) found that women's access to technology was comparable to men's, and that they were more likely to complete the course and twice as likely to pass it. Hence, he questioned the notion that women were disadvantaged by access to technology and proposed turning to the issue of why women excelled in online environments. Through a questionnaire survey of a sample of online course participants with an equal gender representation in responses, he examined gender differences in academic engagement. He found that for the online course, women were more academically engaged than men in terms of self-confidence and their willingness to learn from other students. Comparatively, men taking the online course had the least confidence among all the gender groups across both versions of the course. Through email interviews of a subset of the survey respondents, he also considered gender differences in conception and perception of tutoring. He found that women tended to have more affective conceptions of tutoring, such as tutoring being pastoral. They valued the online affordances for networking across spatial boundaries, especially for female respondents who lived in remote places. They also valued the online affordances for social interaction such as chatting. Price (2006) suggested that the focus of the gender debate needed to shift from access and performance to the importance placed on different interactions and tutoring styles online.

There are studies that suggest shifting the focus further away from gender to how students optimize the use of technologies for online and blended learning. In addition to providing students with blended learning environments, students should also be able to use the technologies effectively for learning. Yen and Lee (2011) studied the problem-solving patterns and learning achievement of 34 students in an undergraduate introductory course on computer networks. Combining cluster analysis and content analysis, they identified three clusters: (a) hybrid-oriented group that participated in classroom, mobile and web-based activities almost equally; (b) technology group that participated more actively in the latter two; and (c) efficiency-oriented group that monitored their learning processes and used mobile technologies only when necessary. Yen and Lee (2011) found that the majority of female participants were in the hybrid-oriented group while the majority of male participants were in the technology-oriented groups. However, it was the efficiency-oriented group, with an almost equal gender distribution, that out-performed the other two groups. Yen and Lee (2011) attributed this to the efficiency-oriented group's engagement in classroom discussion and report writing as modes of monitoring their learning.

Taken together, the studies presented should not be taken to mean that gender does not mat-

ter in e-learning. In fact, these findings merely highlight that gender differences in the mere participation in learning activities or mere use of technology alone do not matter. What matters as well are other factors, such as meta-cognition, that enhance the learning that may accrue from participation in learning activities and from the use of technology. Therefore, even if females (or males) were to be disadvantaged in terms of access to and experience with technology, this might be compensated for if they were able to optimize their use of technologies for learning. The important implication of these studies is that for technology-mediated curriculum to be gender-inclusive, it needs to provide equal opportunities for both male and female students to participate productively in modalities of online and blended learning such as communication and collaboration. Having classroom discussion to engage learners and to monitor their learning may help both male and female engineering students.

Curriculum Designer: Male of Female?

Many games have been designed by male game designers and that has been an important influence on game design and the end user. Dickey (2006) noted that "technology and design are rarely value neutral, and beliefs and values are perpetuated through design" (p. 789). She was concerned that this would lead to the perpetuation of cultural values that existed in society and that tended to limit female roles and participation. Miller, Chaika, and Groppe (1996), who conducted group discussions with 30 female students aged six to 12 after sessions of them trying out games in a supervised setting, found that girls preferred games that were collaborative, challenging, and that included elements of problem solving and features offering positive feedback. The girls expressed a preference for games that provided real life simulations and role-playing associated with a variety of careers. They were interested in games that offered them an experience of what life would be like if they were to embark on the chosen career, the educational requirements, salary expectations of the career, and the lifestyle.

In contrast, Dickey (2006) observed that video games available in the market, which were often designed by males, tended to suffer from gender stereotyping with females being portrayed as people who needed to be rescued through the actions of the male characters of the game, and that the activities also tended to show violence towards female game characters. She noted that harassment of female players also occurred in terms of aggressive language and gameplay actions beyond the character roles.

Cassell (2002) suggested that the design of technology should be underdetermined so that users themselves had the choice to implement their own preferences. She referred to McIntosh's (1983) paper which described how women were viewed in curriculum design in fields such as history. McIntosh (1983) posited that there were five phases of curriculum design that took gender into consideration. In the first phase, women were not considered in history as history only focused on the privileged world of white men. In the second phase, there was a focus that included a few famous women in history. In the third phase, history acknowledged women, not as the norm, but rather as a problem for the scholar. In the fourth phase, history explored the private domestic spheres of women and finally, in the fifth phase, curriculum revision involved the reconstruction of history to include women as a whole. Cassell (2002) pointed out that, in technology, we should strive towards an interface design that is radically reconstructed to include both men and women, and that benefits the needs and preferences of all. Similarly, the authors argue for an e-learning engineering curriculum design that benefits both men and women studying engineering that this is more likely to be achieved if females are part of the e-learning curriculum design team.

Hence, the authors propose that, for the design of a more gender-inclusive e-learning curriculum, it is important that females be part of the design team to ensure that discourse fostering collaboration and communication components in the e-learning environment that appeal to female engineering students are included in the curriculum. Collaboration will encourage students to share information with each other, to analyze, synthesize and evaluate the information given, and to propose solutions to problems. Having a more gender balanced curriculum design team will help to cater to the needs of both male and female students that will result in higher levels of participation and engagement in engineering classes.

SOLUTIONS AND RECOMMENDATIONS

Proposed Checklist for Designing an E-Learning Curriculum

In many areas of the world, women are still under-represented in engineering education. In Asia-Pacific countries such as Japan, Australia, Canada, and the United States, the proportion of women enrolled in engineering is far less than that of men. For example, in Canada, at the undergraduate level, women only represented 20% of all students enrolled in engineering, architecture and related disciplines in 2008 (The Association of Universities and Colleges in Canada, 2011). Kaspura (2012) reported that women accounted for 14% of acceptances places in engineering courses in Australia. In Japan, females represented 14% of science and engineering students in universities because they were thought to be socialized into the gender track and that there was a hidden curriculum in elementary high school where girls were encouraged to be good mothers and wives (Baker & Viseman, 2009).

To attract girls into engineering, the key may lie in the changing of their perceptions of the desirability of the university engineering course. As researchers who live and work in the Asia-Pacific region where males still dominate in engineering, the authors propose the following checklist to help engineering educators, who work in similar contexts in other parts of the world, design an e-learning curriculum which is more appealing to female students. The authors believe that using this checklist will help engineering faculties to design an e-learning curriculum that will be more gender-inclusive in nature and that will help in the engagement and retention of engineering students, especially female students.

1. Are there mixed-sex groups in which there is an equal balance in the proportion of male and female students?
2. Is there a buddy system for the less able students?
3. Is there a mentor system for less able students?
4. Have you designed collaborative activities that taken into account the communicative needs of the learners?
5. Have you explained the rules of turn-taking in online and face-to-face discussions?
6. Have you offered additional help to students with less prior experience before the course?
7. Have you offered additional help to students with less prior experience during the course?
8. Are there appropriate communication tools specified in the e-learning curriculum?
9. Have you written guidelines on questioning techniques for the communication tools?
10. Have you conducted training for these questioning techniques?
11. Have you included females in your curriculum design team?
12. Have you included face-to-face classroom discussion in addition to online communication tools?

FUTURE RESEARCH DIRECTIONS

There is definitely a potential for simulation games to be used in more freshmen engineering classes in the world to ascertain whether what worked in the American context is applicable in other higher institutions worldwide. A longitudinal focus would certainly be welcome as it would be interesting to investigate whether there are long-term effects of such games on the identity of female engineering students as engineers.

It would also be fruitful to investigate how male students in engineering courses respond to the communication tools and the collaborative activities proposed in this chapter. Examining the extent to which male students improve their turn-taking skills in online forums or classroom discussions or the reading of non-verbal cues as a result of having more females in their groups is also worthwhile.

One of the future research directions might be the digital medium itself in engineering education. The point made by Jan (2013) of distinguishing games as a technological innovation and pedagogical innovation recalls the point that has been attributed to Henry Ford "If I had asked people what they wanted, they would have said faster horses." E-learning tends to look to technological improvements in the digital medium for pedagogical innovation. However, one might wonder if similar pedagogical benefits may be had with improved affordances of more traditional media. For instance, Tan, Jan, and Tan (2013) noted that digital role-playing games, such as Massively Multiplayer Role-Playing Games, that are said to be made for learning, have a lineage that can be traced to non-digital forebears (Hitchens & Drachen, 2008; Indvik, 2012). In their study of how expert gamers play a paper-based card game, they noted that play was directed towards collaborative problem-solving in three distinguishable modes: collaboration, dialogic argumentation, and role-playing, during which players assumed professional identities that framed argumentation. A possible future direction is to study how traditional media may be reinvented to offer pedagogical affordances for both genders to inform a gender-inclusive e-learning curriculum design in engineering courses.

CONCLUSION

The purpose of this chapter was to examine how studies of game-based learning can inform the design of an e-learning curriculum in male-dominated fields such as engineering and architecture so that the curriculum will engage both males and female students, increasing their motivation and participation. The authors have suggested that the following need to be taken into consideration in the design of such a curriculum: (a) mixed-sex groupings, (b) collaborative activities, (c) peer and expert help, (d) use of communication tools, (e) blended learning, and (f) inclusion of females in the curriculum design team. The authors suggest that a curriculum that takes into account the above should engage female engineering students more and help them develop their identity as engineers. With more females remaining in engineering, gender balance in workplace teams will move towards parity, which will improve group processes, resulting in higher levels of collective intelligence as shown by Woolley et al. (2010). This in turn will lead to, as Bear and Woolley (2011) have argued, teams creating more innovative products and scientific discoveries as female engineers will contribute new perspectives, pose new questions, and propose new or improved products that will benefit the other half of the world's population.

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KEY TERMS AND DEFINITIONS

Blended Learning: A teaching and learning approach that combines face-to-face sessions with online activities.

Collaboration: The act of working jointly with others on a shared goal.

Communication Tools: The tools that allow learners to learn and interact with each other, and the instructor(s).

Discourse Marker: A word or expression that indicates how one part of a discourse or conversation is connected to another.

Engagement: The participation of learners in the activities offered in the course.

Gender: A cultural construct of femininity and masculinity as opposed to the biological sex that humans are born with.

Simulation: A miniature and controlled version of a sphere of concrete activities in real life where learners can experiment with various aspects of reality that would be impossible to examine outside of real life.

Turn-Taking: The process by which two or more people in a conversation decide who speaks next.

Section 3

Architecture Cases

Chapter 15
Learning GIS in Architecture:
An Educational Experience to Improve Student ICT Skills

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ABSTRACT

The introduction of Information and Communication Technology tools in the architectural practice can be challenging. This chapter discusses an educational approach to teach Geographic Information Systems to architecture students in the Barcelona School of Architecture. The methodology uses a combination of theory lectures, worked-out examples with faded guidance using a real-world case of study, and self-directed discovery in a project-based learning activity. The results of pre-course and post-course surveys are also discussed to illustrate the workflow of students when using spatial data, their perception on using GIS applications, and their impressions regarding the development the course. Finally, the possible reasons for the limited adoption of these tools in the architectural field are also discussed.

INTRODUCTION

Information and Communications Technologies in Architecture

Although the roots of the architectural profession span back for millennia, the use of Information and Communications Technologies (ICTs) in the knowledge areas of architecture (Penttilä & Weck, 2006) and urban planning (Norte Pinto, Lancrenon, & Berchtold, 2014) has not been uncommon since the beginning of the century (Rivard, 2000): architects increasingly use software tools to visualize the building in different stages of the design process; to analyze the behavior of structures under different loads; to optimize the HVAC (Heating, Ventilating, and Air Conditioning), sewage, plumbing and electrical systems; to estimate the cost of buildings before they are built and control the expenses and scheduling

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during their construction; to simulate the effects of solar radiation and wind dynamics: to calculate the thermal and noise insulation required; to produce, manage and transmit documentation in team collaboration; to search information about technical specifications, regulations and competitions; and to disseminate the results of their work to customers and fellow architects, among others.

However, these skills rarely receive formal training in the field of architecture, possibly because the quick pace of technology added to the extended duration of architectural studies makes the knowledge of many of these tools obsolete during the course of the students' tuition. Nevertheless, the authors believe that strong ICT skills provide students with the right tools to adapt to technological change effectively (Stone Wiske et al., 2001) and should be included in the formative years of the architectural education (Wang, 2009, 2011).

In addition, part of the architectural profession is wary of the introduction of ICTs in their practice, ignoring its benefits (Moum, 2006) because of the perceived disruption in the established workflows, even though technology can be a valuable tool to deal with the increasingly short turnaround times of architectural design projects. In addition, the belief that new tools can interfere in the creative process (Şenyapili & Basa, 2006) makes their adoption difficult; while it is obvious that the introduction of a novel technology in a discipline can have a great impact in its development, the successful incorporation of new items into the professionals' toolbox (Bouchlaghem, Shang, Whyte, & Ganah, 2005) should translate into a richer creative environment, even in the earlier stages of design (Knight, Dokonal, Brown, & Hannibal, 2005).

Geographic Information Systems in Architecture

The complexity of the architectural work involves dealing with a plethora of different inputs. In the architectural field, the "genius loci", or the principle that architecture must adapt to its context is seldom disputed; therefore, the concept of place (the location of the architectural object but also its socio-cultural and historical background) is of utmost importance and permeates all the stages of the conception of the architectural form.

Geographic Information Systems (GIS) are used in multiple knowledge areas when the object of study has a spatial component (geography, ecology, economics, sociology, transportation, etc.). The capacity of GIS tools to relate multiple layers of information from different sources through its geolocation in multiple scales with high geometric accuracy is very valuable in various areas in the architectural field: urban and territorial planning, project design, landscape architecture, real estate valuation, and heritage conservation.

Despite the suitability of GIS tools for the multifaceted and multidisciplinary nature and the complex demands of contemporary architectural practice, its adoption has not been as enthusiastic as with CAD (computer-aided design) and CAAD (computer-aided architectural design) or, more recently (Çetiner, 2009), with BIM (building information modeling). This chapter tries to explain the limited adoption of GIS tools by architects.

GIS Education in the Barcelona School of Architecture (BarcelonaTech)

Lecturers should spearhead the introduction of new technologies (Epper, 2001); however, the experience of the authors is that the penetration of GIS tools in architectural higher education is small, possibly because of the lack of familiarity of the teaching staff with its capabilities and the perception that it interferes with the creative process instead of enhancing it (Paar & Rekittke, 2012).

In the Barcelona School of Architecture, due to the cross-departmental nature of the subject matter, an introductory course using GIS technology has been offered since 1994 as an elective

with 4.5 ECTS (European Credit Transfer and Accumulation System) credits. In addition, the Technical University of Catalonia has been offering a Master's Degree in GIS in its School of Professional & Executive Development, and postgraduate courses using GIS in the Master's Degree in Urban Management and Valuation and the Master's Degree in Landscape Architecture.

This chapter explains the educational methodology shaped over several years in the different editions of these courses to teach GIS to architecture students and architects.

Objectives of the Chapter

This chapter explains the educational approach to help architecture students acquire ICT skills to understand the conceptual foundations of GIS software and its practical applications in the architectural and urban planning fields. Its objective is to help educators effectively provide learners in the architectural field the necessary skills to acquire a solid foundation using GIS technology.

To determine the students' requirements when using these tools, the results of pre-course and post-course surveys are also discussed to examine the current adoption state of GIS tools by students, their workflow when working with urban data, and their perceived confidence using ICTs.

BACKGROUND

GIS Education

Literature on using ITCs in architectural education is rare. Some innovative experiences are worth mentioning using Augmented Reality (AR) to visualize architectural projects (Fonseca, Martí, Redondo, Navarro, & Sánchez, 2014), and using AR enhanced with geolocation on mobile devices (Redondo, Puig, Fonseca, Villagrasa, & Navarro, 2014) to improve students' ICT skills and enhance their comprehension of the studied subject.

Literature regarding the use of GIS in the architectural profession is even more scarce; at the time of writing, a query of the keyword "GIS" in the Cumulative Index of Computer Aided Architectural Design (Martens & Turk, 2015) returns 238 results of 11,700 records (around 2%), and most of the results can be considered only tangentially relevant. When narrowing down the query using terms related to education (e.g. "education", "teaching", "learning", etc.), the number of results drops to under ten records.

However, the benefits of using GIS tools to explain spatial reasoning (Edelson, 2013) can be useful since secondary education (National Academies Press, 2006) as well as in higher education (Sinton, 2012), as they allow students to not only read about analyses but also to perform analyses themselves (Kerski, 2003).

Furthermore, the definition of space is at the core of the architectural practice (Hillier, 2007). The advantages of using GIS tools to better contextualize the locations of architectural students' projects using a multi-scale approach and to integrate multiple sources of information, along with the possibility to visualize the 3D urban environment have been studied (Mustapha, 2009).

In addition, GIS education in the closely related and partially overlapping discipline of civil engineering has also been discussed (Luna, Hall, Hilgers, & Louis, 2010), as well as in the field of landscape architecture (Paar & Rekittke, 2012). In the regional scale, the benefits of using GIS tools in geography education have been demonstrated since the decade of 1990s (Kemp, Goodchild, & Dodson, 1992; Sui, 1995).

Finally, being CAD and GIS complementary and closely related technologies –some GIS software have their roots as extensions of CAD packages–, the introduction of GIS concepts to architectural CAD users (Chen, Zhao, Chen, & Yang, 2011) can be a valuable strategy to help learners assimilate a geospatial-aware framework. For raster data, the analogies with commonly used tools like spreadsheets (Raubal, Gaupmann, &

Kuhn, 1997) or image editors (Ratti & Richens, 2004) can also help understand the operations when working with gridded data.

Educational Methodology

People learn more effectively when they can build on what they already understand. The constructivist approach to knowledge acquisition (Papert, 1980) based on the work of Piaget, argues that learners internalize new knowledge into their internal framework through accommodation (reframing existing knowledge to fit new one) and assimilation (incorporating new knowledge without altering existing one).

Constructivism is often applied through the hands-on approach of "learning by doing", using experimentation and self-directed discovery instead of lecturing; however, there are some caveats to this minimal guidance approach (Kirschner, Sweller, & Clark, 2006) specially in the case of novices, which are fundamentally different than experts (Bransford, Brown, & Cocking, 2000).

Using guided practice provides learners with a structure and also has added benefits over pure discovery (Mayer, 2004); the worked example approach (Sweller, 1988) follows the progression of learners beginning with worked examples with step-by-step solutions, and progressively decreases the amount of guidance into more open-ended problem solving. This "guidance fading" strategy allows learners in the early stages of schema acquisition to focus on understanding the concepts and building mental models that will be practiced later (Renkl, Atkinson, Maier, & Staley, 2002), starting with an example followed by increasingly more incomplete exercises and ending with a problem to be solved autonomously. This strategy, however, can be pedagogically –although in the case of adult learners in higher education we should refer to andragogy instead of pedagogy– counterproductive in the case of experienced learners that do not require guidance (Kalyuga, Ayres, Chandler, & Sweller, 2003).

Case studies has been extensively used as a teaching method in urban planning and architecture, as well as in business and legal education. Problem-based learning (PBL) is a learning methodology focused on the experience of problem-solving. These problems can be solved in multiple ways, which promote critical thinking, the acquisition of real-world skills and the capacity to adapt to new paradigms (Edens, 2000), attributes appreciated by prospective employers (Vardi & Ciccarelli, 2008) since they promote effective thinking.

Mixing PBL activities with traditional lectures is also possible and can be beneficial (Hung, 2011). Experiences using PBL in the instruction of GIS by determining the optimal location of a school (Drennon, 2005) or analyzing the location of historic buildings (Summerby-Murray, 2001) have been discussed in the literature.

Learning Strategies and Individual Considerations

The group of students that attend the course has historically been quite heterogeneous regarding their gender, age and origin, as identified in the surveys. In the instruction of an heterogeneous group of learners, their individual capabilities have to be taken into account (Millrood, 2002) and different strategies have to be used to cater their individual needs and make the educational process engaging for all of them (Leaver, 1993). In this chapter, the strategies adopted to accommodate the different characteristics of the students are discussed.

According to the Bloom taxonomy (Engelhart, Furst, Hill, & Krathwohl, 1956), students can achieve different levels of knowledge, and instructional material should adapt to the intended skill level that are expected to achieve (Orey, 2001). Regarding their attitude towards the learning process, the literature has broadly classified the students between "surface learners", "strategic learners", and "deep learners" (Bain, 2004); while

the first two categories aim for a specific grade (passing grades for surface learners and higher grades for strategic learners) and eventually forget many of the concepts learnt, only deep learners integrate the new knowledge into their conceptual framework.

Within the Zone of Proximal Development (ZPD) of a learner lies the tasks that the learner can do with guidance (Vygotsky, 1978). This zone is between the tasks that the learner can do unaided and the tasks that are outside the scope of his or her capabilities whithin a given stage of knowledge acquisition. Scaffolding (Wood, Bruner, & Ross, 1976) is a process where a teacher aids a student within his or her ZPD and –as in its building construction analogy– gradually removes the aid as the student becomes more autonomous. Once a level is achieved, the process can be repeated for the next ZPD –in the construction analogy, building a new story–. Scaffolding can be used in a PBL environment (Schmidt, Rotgans, & Yew, 2011) and the process can benefit from using e-learning technologies (Yelland & Masters, 2007).

Finally, when working with novice learners, educators must be aware of the Dunning-Kruger effect (Kruger & Dunning, 1999; Ehrlinger & Dunning, 2003; Ames & Kammrath, 2004): since at the beginning of the learning process the students absorb a large amount of knowledge in a relatively short amount of time, and do not yet possess the skills to evaluate their own competence, they tend to overestimate their capacity.

EDUCATIONAL EXPERIENCE TEACHING GIS IN ARCHITECTURE

The present educational methodology has been developed during the previous 20 editions of the GIS elective in the Barcelona School of Architecture and in various Master's Degrees programs (Master in Geographic Information Systems, Master in Urban Planning and Sustainability, Master in Landscape Architecture, and Master in Urban Management and Valuation).

The elective on which this methodology was tested is an intensive course that runs for five consecutive days (beginning on a Tuesday and finishing on a Monday) from 9AM to 7PM with short breaks approximately every two hours and a lengthier break of about an hour for lunch. The elective is offered at the end of the first semester every academic year and the number of students usually hoovers around 20-25 people.

Specific Needs of Architects and Architecture Students

The complexity of the architectural professional practice (Schön, 1984) requires of ICT tools adapted to the specific needs of architects. Like other creative activities, architects have a distinct way of thinking during the design process (Cross, 1982).

In the field of architecture, the authors have identified (through informal interviews with students, educators and professionals) some specific demands when working with GIS tools:

1. Easy interoperability with other software, allowing to easily import and export among others to CAD/CAAD tools, 3D packages, spreadsheets and image editors,
2. Accommodate the way architects think about space, both in orthographic view and three-dimensionally,
3. Have the geometric precision and control over the representation to guarantee a high quality output, and
4. Be suitable to be used as an analysis, creation and representation tool because these activities are usually addressed simultaneously.

The educational methodology of many schools of architecture is based on the premise that the architecture student is an architect in training,

and therefore the needs of professionals needs are very closely aligned to the needs of students. This makes the adoption of a new technology attractive to students as long as it is perceived as a valuable asset to improve their work, at present or in the future.

GIS has the potential to fulfill some of the requirements of the architectural workflow that other tools cannot, reducing the workload in repetitive routine tasks and being an enabling technology that allows access to data that is publicly available but difficult to work with: topography stored in digital elevation models (DEM), manipulation of big data regarding urban phenomena (Offenhuber & Ratti, 2014; Tang, Auffrey, & Lu, 2013), planning regulations, etc.

In addition, with the increased mobility of architectural professionals, the standardization of planning regulations with an abstraction layer provided by GIS can be perceived very positively by students, since 35% of EU-25 architects cite "insufficient knowledge of planning / building regulations" as an obstacle for working in another country, which rises to 45% for Spanish architects (Architects' Council of Europe & Mirza & Nacey Research, 2012, p. 59).

The following sections explain the educational approach adopted to teach GIS to students in the Barcelona School of Architecture and discusses the results of the surveys conducted before and after the course.

Physical Setting

The computer lab where the course has been taught in the most recent editions is equipped with an overhead projector connected to the instructor computer. Beside the projection screen there is a whiteboard that can be written using color pens and a 50cm podium runs along the length of the wall where the whiteboard and the screen are.

The students' computers are laid in five rows of four computers each and the instructor desk is on the podium. Depending on the number of students some of them have to share a computer but the majority have an individual Windows PC with internet connection where the software used (the ArcGIS Desktop mapping suite from ESRI) is installed.

Paradoxically for an ICT focused subject, the authors have found that the use of a (low-tech) drawing board improves communication with the students: when sketching a diagram or explaining an example, the fact that the drawing is being drawn in front of their eyes and is not complete until the process is finished adds an element of interest that helps the students focus on the explanation. In addition, drawing is an activity that architecture students regularly engage in, and helps adding an element of improvisation and establish a dialogue with the students in a language they are familiar with.

It is worth mentioning that the students farther away from the projection screen valued the course lower in the surveys conducted by the authors (Garcia-Almirall, Redondo, Valls, & Corso, 2014) specially in the fourth and fifth rows. While it is not possible to determine if this is the result of self-selection (more interested students seating closer to the screen) or other confounds without conducting a randomized controlled experiment, the authors speculate that there is a sweet spot where students can see the projection and hear the explanation without difficulties, while the students of the last rows are subject to a greater cognitive load to follow the class.

Teaching Blocks

The canonical approach divides the learning process into two blocks: theory and practice. Although the course was eminently practical, as discussed in the literature novice learners can benefit from the combination of lecture-based theory classes and practical exercises.

Based on previous educational experience, the authors extended this approach and the syllabus was divided into four blocks, further breaking practice-oriented activities into three distinct sub-blocks:

1. Introduction to the use of the software,
2. Practical exercises, and
3. Self-directed innovation proposal using GIS technology.

The classes were divided roughly into 15% theory and 85% practice, being the practical exercises about half of the instruction (Figure 1).

In introductory courses, it is difficult to understand the theoretical underpinnings of a practical application without gaining some hands-on experience, and at the same time, it is challenging learn the rationale behind a discipline through a pure practical approach. This conundrum that arises when teaching ICT courses was tackled intertwining theory and practice in the introductory section.

The first third of the course alternated theory classes and synthetic self-contained practical exercises. The result was a synergistic combination of theory and practice that allowed learners begin to understand the theoretical framework of GIS and its applications simultaneously. As an example, if a the representation of data in a choropleth map was explained in a lecture, the students would able to experience first-hand the generation of said map in their computer in the following practice, and likewise, if they loaded a raster dataset in a practice, they could be explained the difference between raster and vector data in the following lecture, having experienced what was being explained. Once this foundation was laid, the practical exercises and the innovation proposal built on it and further strengthened the student comprehension: the practical exercises in a guided manner and the innovation proposal autonomously.

The practical exercises were the central part of the course, both chronologically and conceptually, and used the fading worked-out example (Renkl, Atkinson, & Große, 2004). They had the largest weight in the course. Finally, the innovation proposal was developed independently by the students over the length of the curse, and its public presentation and discussion wrapped up the course in the last session.

Theory Classes

Although the course was eminently practical, in the introductory phase of the course the conceptual framework and the basic terminology of GIS was laid out in lecture-based theory classes. The format of the lecture was of a master class with the support of the projector but stress was put upon establishing a discussion and interact with the students on the topics covered.

Real-world examples of research projects involving GIS were used to illustrate its potential in several fields (land management, cadaster, urban planning, and public participation) and explain the

Figure 1. Chronogram of the course

benefits of using this technology. The examples were also used to explain the basic terminology and the specifics of handling spatial data.

These examples explained the process from the initial stages to the final results and were chosen with two main criteria: (a) they had to be interesting to architecture students (i.e. the results had to be attractive, difficult to obtain with other tools, and showcase its applicability in their daily workflow), and (b) had to cover a wide range of topics, in order to provide students with a broad perspective on the capabilities of GIS tools, which was needed to successfully complete the innovation proposal using GIS technology that had to be developed during the length of the course.

Introduction to the Use of the Software

To counterbalance the theory classes and illustrate some of the topics covered there with some hands-on experience, an introduction to the use of the software that would be used in the practices was run in parallel to the lectures. The format of this introduction was of a worked-out example and was autonomous from the practical exercises that would follow. Support material was provided in the university intranet to aid students following the practice and use it as reference in the practical exercises.

The strategy was to isolate building blocks to be understood independently and practice these separately using synthetic examples. Analogy to features of commonly used software (CAD/CAAD, image editors, productivity) was used to illustrate its similarities and highlight its fundamental differences.

Some examples of the skills practiced were:

1. Handling of files and workspaces,
2. Navigating the map window,
3. Change the symbolization of entities based on attributes, and
4. Open a related table. These non-contextualized skills would be later articulated in the practical exercises.

Practical Exercises

The main part of the instruction was the guided practice, which accounted for about half the course and was taught after the introductory section. Having introduced the conceptual framework and elementary skills using the software in the previous section, the practical exercises could be developed smoothly because the foundation on which to build had been already laid out, and the flow of the practice was not interrupted having to explain basic concepts.

The practice was based on a single case of study based on a real case developed in a research project. The advantages of using a single case of study (as a sort of "virtual" situated learning) were twofold:

1. It allowed the students to concentrate in a single case without having to familiarize themselves with multiple settings, focusing on the practice instead, and
2. Highlight the multifaceted approach that can be used when working with GIS in a complex area, allowing the integration of multiple sources of information.

This section used worked-out examples with faded guidance as its educational methodology: the exercises were initially solved "live" by the instructor, with the students repeating the steps in their computer, and progressively reducing the amount of supervision (using instructional scaffolding) until the students were able to solve the problems by themselves.

The process adopted was the following: in each exercise,

1. The instructor explained its goals and the students were asked to solve the problem in a given amount of time;
2. During this time, the instructor or instructors walked around the class discussing the work done by the students individually, which were also encouraged to talk to each other to find a solution;
3. After the time allocated was over, the instructor solved the exercise in front of the students using the overhead projector and discussed the exercise with the whole class. Considering the role of the instructors as facilitators, this approach needed the ratio of students/instructor to be sufficiently low.

This technique needed that each new exercise, with its corresponding reduction in the level of support, kept the new concepts within the ZPD of the students. However, since the skills and motivation of the students were heterogonous, to cater the needs of all the class the following approach was used: in each exercise, the students were asked to solve a problem, which constituted the baseline knowledge that they were expected to acquire; however to cater the needs of the more advanced and/or motivated students, the students were challenged to solve a harder exercise in the allotted time in addition to the regular one. The experience of the authors is that the majority of the students attempted to tackle the harder exercise, and almost all the students were able to reach the baseline goal.

Being novice learners, the students could fall into the Dunning-Kruger bias and overestimate their own skill because of their quick advances using the software. To help them avoid this, each exercise was progressively more complex and the analyses were more nuanced: sometimes a previous exercise was revisited after learning a new concept to correct some conceptual error, and on occasion some intentional "traps" were introduced in the exercises for the learners to fall inadvertently into.

A handout was made available to the students in the university intranet (Garcia, Valls, & Moix, 2011) so they were able to follow the class easily. This document helped the students if they got stuck in the practice, reducing their anxiety, and helped them review the work at home. In addition to being a step-by-step guide, the main advantages of this guide were twofold:

1. Although it was explained in class, it described the goals of each part of the practice in writing so the students could have a reminder of its objectives, and
2. It provided illustrations of the intended results so they could have an indication of what they were being asked to do.

The practice was broken into three blocks:

1. Data import,
2. Working with cadastral data, and
3. Working with 3D data.

They were designed so the student realized that complex analysis could be performed combining multiple simple operations intelligently.

Data Import

Architecture students work with a multitude of software packages and therefore value interoperability highly: if they have to learn a new application it has to integrate with their established workflows.

The first block of the practical exercises focused on importing external data, either self-generated or downloaded from the Internet:

1. Planning information from a CAD file,
2. Census tracts information stored as flat text files,
3. Georeferencing a scanned image, and (d) fetching an orthoimage from a WMS (Web Map Service). In addition, formatting data

and producing a map according to a particular standard (Departament de Territori i Sostenibilitat, 2015) was also practiced.

Indirectly, these operations were used to practice selection operations, table joins, symbolization of attributes and spatial reference definition.

Working with Cadastral Data

The cartographic and tabular cadastral data are publicly available (Dirección General del Catastro, 2015) for the whole Spanish territory; since the cadastral database contains the vector representation of the geometry of the parcels and the simplified 3D geometry of the buildings, it is very valuable in the field of urban studies. In addition to the vector data, the tabular data contain information about uses, year of construction and built areas (among other information) using a single uniform criteria. Knowing how to work effectively with this information is very valuable for architecture students.

This block was divided into two parts: the first consisted in calculating the weighted average of the age of the buildings in a parcel, taking into account that different parts of a building can have different years of construction; the second part was the estimation of the transformation potential of ground floors facing a commercial street in a change of use scenario. This second part involved importing planning cartography as explained in the previous block (data import) autonomously by the students.

In this block the students worked with graphical and tabular data and practiced aggregating data, generating new information from existing data and storing it in a field, performing selections using topological relations, and interpreting null values resulting from table join operations.

Working with 3D Data

In the last block of the practice, the students worked with 3D data from the Spanish cadaster. In the literature, some authors argue that 2D representation of maps is more suitable in learning environments than 3D representation (Niedomysl, Elldér, Larsson, Thelin, & Jansund, 2013). However, the authors believe that the specific scenario used in the course is fundamentally different that the ones described, since the 3D representation is the result of the actual 3D nature of buildings; when architects conceive buildings they conceive them in 3D, using 2D plans, 3D modelling, physical models or hand-drawn sketches. Therefore, the students also practiced the representation and analysis of 3D data in a 2D planar projection.

This block focused on

1. The creation of a translation table to convert the alphanumeric coding of heights into a numeric value of the number of floors,
2. Spatially relating the planned height and actual height of the buildings,
3. The representation of 3D information in a 2D map, and
4. Working with real 3D data in a virtual 3D environment.

This last block of the practical exercise was the most engaging for the students since they could visualize the area of study in 3D from the extrusion of 2D polygons, a process that they have to painstakingly craft manually when using CAD software (Figure 2).

In this block the students practiced overlay operations and the representation of the results of their analysis in 2D and 3D. In addition, they had the opportunity to use previous learnt skills (table joins, aggregation operations) for different purposes than in the previous block.

Innovation Proposal

The Bologna Process takes into account inside the workload of the learning activities the self-study of students (European Commission, 2009). As a self-study activity, the students were asked to

Figure 2. Final result of the 3D practice, exported to a 3D package

develop an innovative application proposal using GIS technology. The innovation proposal goals were explained the first day of the course and the students were asked to develop it during the length of the course; the last day of the course a public presentation (using a format similar to a product pitch or a PechaKucha) followed by discussion wrapped up the course.

This strategy used a PBL approach and was used to counterbalance the practical exercises with a more self-directed learning activity. Inspired by the Harkness Discussion Method (Phillips Exeter Academy, 2015), taking advantage that verbal interaction is critical in determining student achievement (Yew & Schmidt, 2012), and that collaborative learning (Barron & Darling-Hammond, 2008; Lebak & Tinsley, 2010) has proven to be a useful learning activity, the students were encouraged to discuss their proposal during the course with their peers, and participate after each presentation.

This approach encouraged the students to think critically on the concepts learnt and creatively use them in an application of they own choosing. Additionally, the completion of activity was on the back of their minds during the instruction, and helped them assimilate the concepts taught into their schemas, and think about real-world applications of GIS in their study and work environments.

Survey Results on User Requirements

The students were asked to participate in pre-course and post-course anonymous surveys using Google Forms (Google, 2015). The objective of the pre-course survey was to find out their workflow when using spatial data and their software expertise, before taking the course. The goal of the post-course survey was to know their opinion on the development of the course and their perception of the subject in the studies of architecture.

The survey used a Likert scale (Likert, 1932) for the majority of the responses to have more detailed data than using binary responses, using different anchors (Vagias, 2006) depending on the type of question and used a five response scale (Cox III, 1980) with a neutral central response. The visualization of the results is ordered according to the degree of agreement (except when order is important, as in temporal information) and plotted in a diverging stacked bar graph (Heiberger &

Robbins, 2014; Robbins & Heiberger, 2011) using a diverging color scale (Harrower & Brewer, 2003).

Some of these results were presented in more extension by the authors in a previous conference paper (Garcia-Almirall et al., 2014).

Using Cartographic Data in Studies and Workplace

To gain insight into the students' use cartographic data in their workflows, they were asked about their intensity of use and their sources of cartographic data in their work and their studies.

Use of Cartographic Data by Activity

The students were asked about their use of cartographic data in four broad categories: building design, urban planning, renovation projects and other kinds of work (Fig. 3) both in their studies and their work.

The intensity of use in the workplace was lower in all categories; probably because in their internships, architecture students usually perform drafting and administrative duties instead of planning and design work and therefore their site-related activities are smaller part of their regular workflow compared to their studies.

The categories where cartographic data use was higher were building design and urban planning, being the use of cartography in the field of urban planning in their studies the most prominent. This suggests that the most fitting knowledge area for GIS in architectural studies would be urban planning.

Sources of Cartographic Data

Regarding the sources used for cartographic data (Figure 4), the online free cartography sources were the most widely used (in decreasing order: web mapping, Google Earth, the National mapping agency and Cadaster). However the intensity of use of the cadastral data was lower than the rest, probably because the difficulty of accessing it and the lack of knowledge that it is publicly available. The disparity of cartographic data city councils make available makes the experience of the students heterogonous, depending on which municipalities they usually develop their work in.

Figure 3. Use of cartographic data in the studies and the workplace (frequency of use as a percentage)

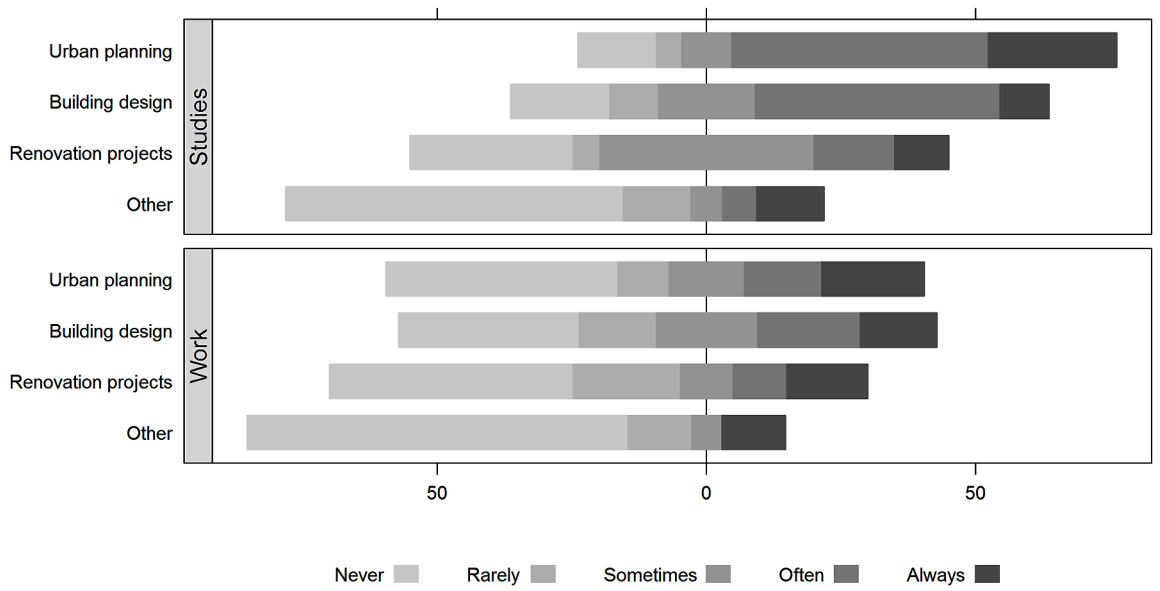
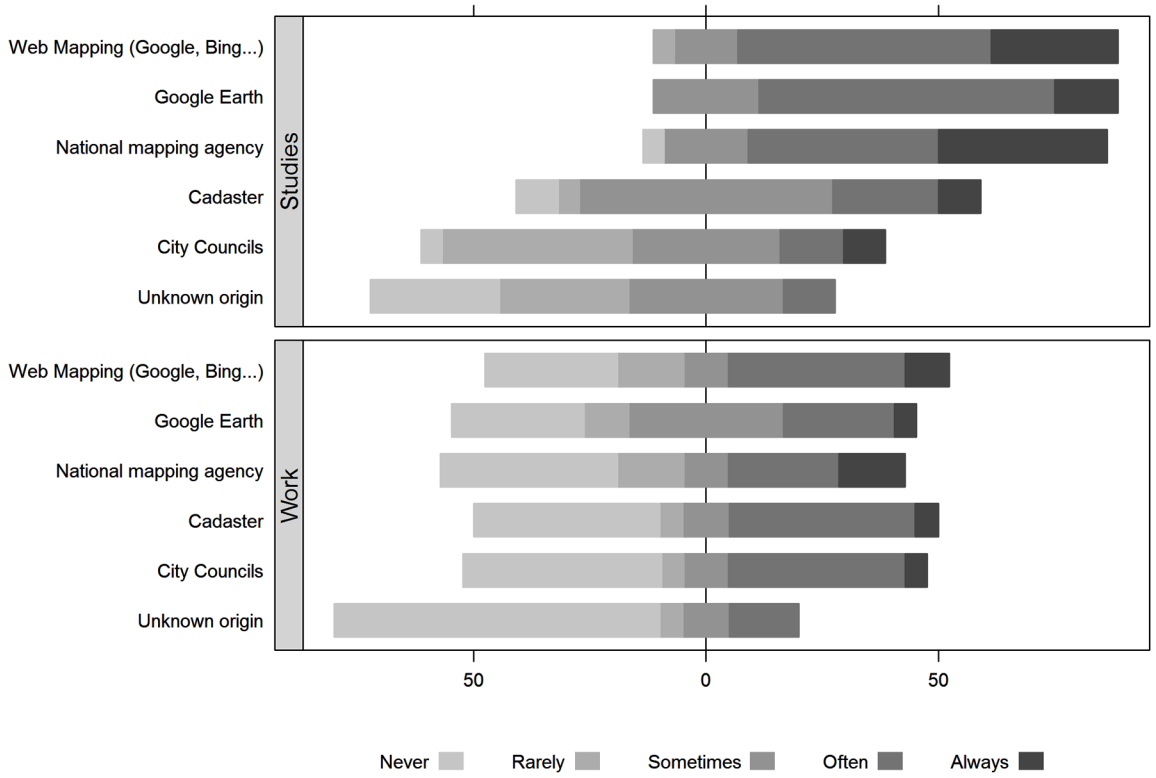


Figure 4. Sources of cartographic data in the studies and the workplace (frequency of use as a percentage)



The course tries to address the discoverability of cartographic data, practicing the different formats each provider makes available so the students gain in-depth knowledge of their applicability.

Techniques Used in Urban Planning

As discussed previously, the design workflow involves a back-and-forth switching between design and representation: in the architect mind the limits between these stages are blurred. This is exemplified in the survey, where an almost perfect parallelism can be appreciated between the two categories.

A seen in the graphs (Figure 5), the usage intensity of GIS is almost negligible, even though other ICTs like CAD, image editors and 3D packages are well represented. Surprisingly, closely related tools like CAD and GIS appear in opposite ends of the spectrum. The next section discussing the results of the survey tries to shed some light on the possible reasons.

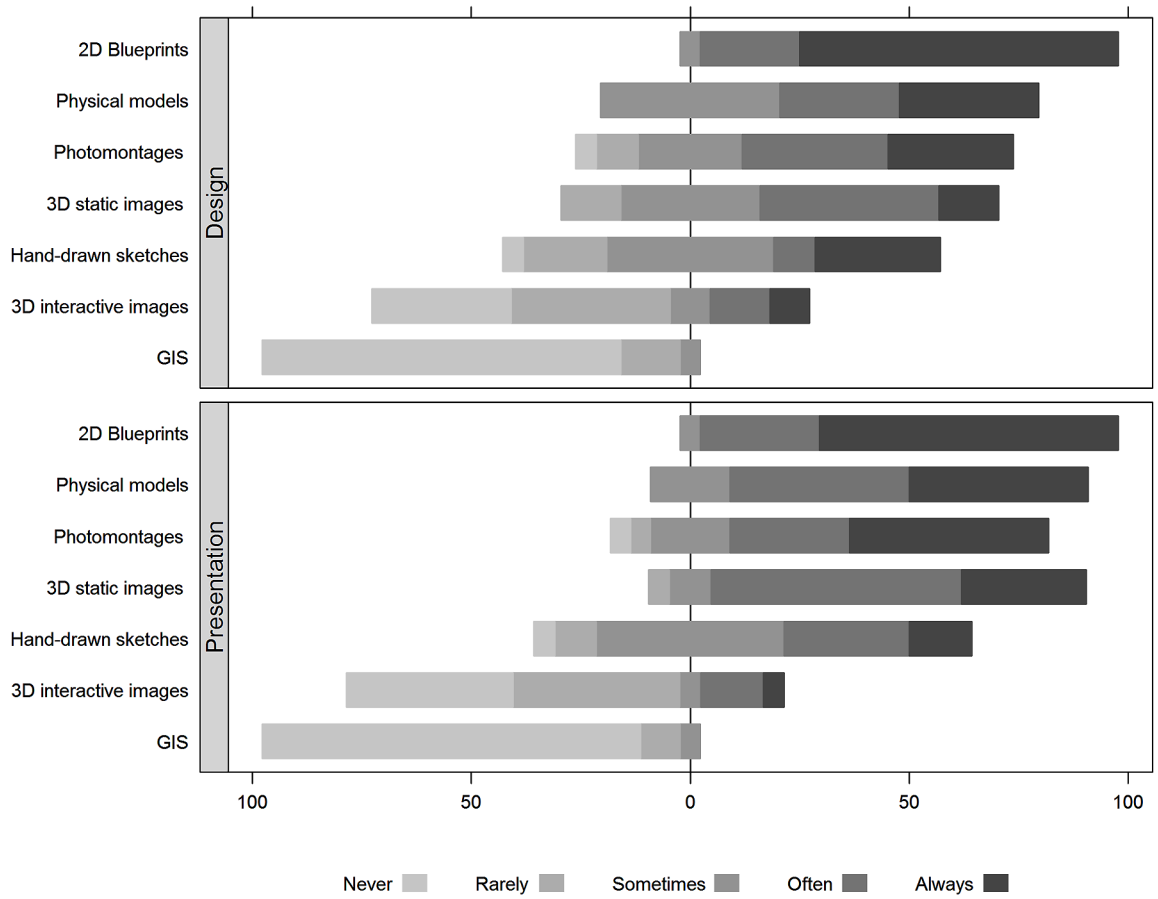
Use of Software Applications

In the survey, the students were also asked about their usage patterns regarding software applications, to identify the fundamental perceived differences between GIS and other software categories.

Software Applications Used

As seen in the graph (Figure 6, top), the intensity of use scale is unsurprisingly dominated by CAD applications, followed by image editors and 3D modelers. At the other end of the scale, BIM tools are seldom used, which is surprising to the

Figure 5. Techniques used in the design and presentation phases of urban planning (frequency of use as a percentage)



authors considering how closely related these applications are to CAD, a fact that draws parallels to the situation of GIS tools.

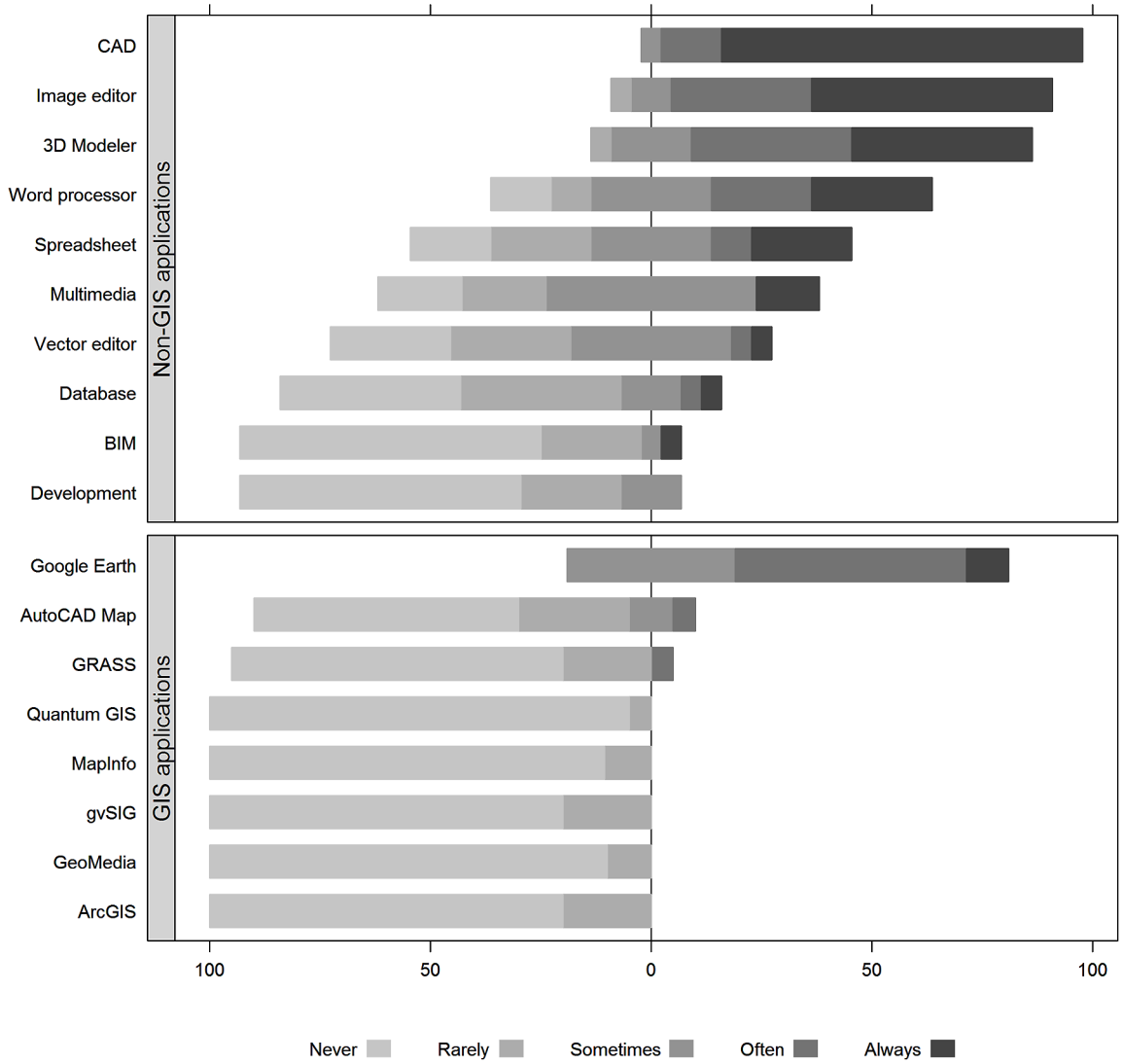
When asked specifically about GIS tools (Figure 6, bottom), the knowledge of the software applications was almost nil, except for Google Earth that, while not a proper GIS application, shares some of its functionality and was incorporated as a control question. The authors speculate that the students consider that Google Earth sufficiently fulfill their geospatial needs.

Attitude towards Software Applications

To find out if there was a fundamental difference in the attitude towards using GIS applications the students were asked about their perceived difficulty using software tools (Fig. 7). The students expressed confidence in using software, learning to use new applications and even mastering them (Fig. 7, top).

Their confidence using applications commonly used in architecture (CAD and 3D) was even higher. However, when asked about using GIS tools (Figure 7, bottom), their confidence dropped notoriously. This results suggest that some mental barriers exist that discourage architecture students to work with GIS applications in relation to other software in general, and specifically in contrast with CAD and 3D software, which are themselves challenging to use.

Figure 6. Use of software applications (frequency of use as a percentage)



The authors propose some explanations for this perceived difficulty:

1. Non-standard user interfaces of the packages,
2. Doubts about their interoperability with other tools, and
3. Difficulty to obtain spatial data structured according to the needs of architects.

Survey Results on the Development of the Course

Motivation to Attend the Course

Being an elective, when asked about their motivation to attend the course (Figure 8), the students mainly valued the usefulness of the knowledge,

Figure 7. Attitude towards software applications (perceived difficulty as a percentage)

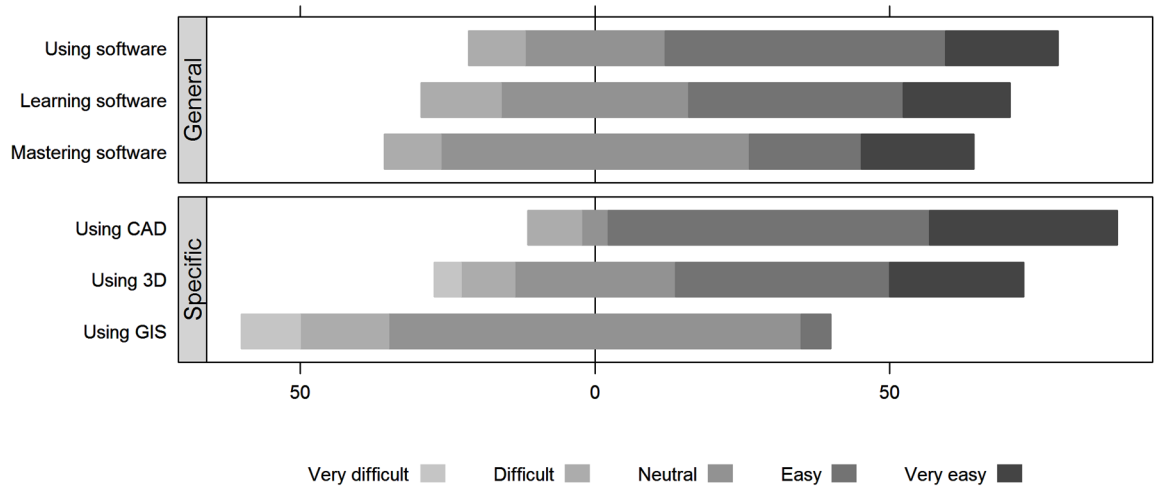
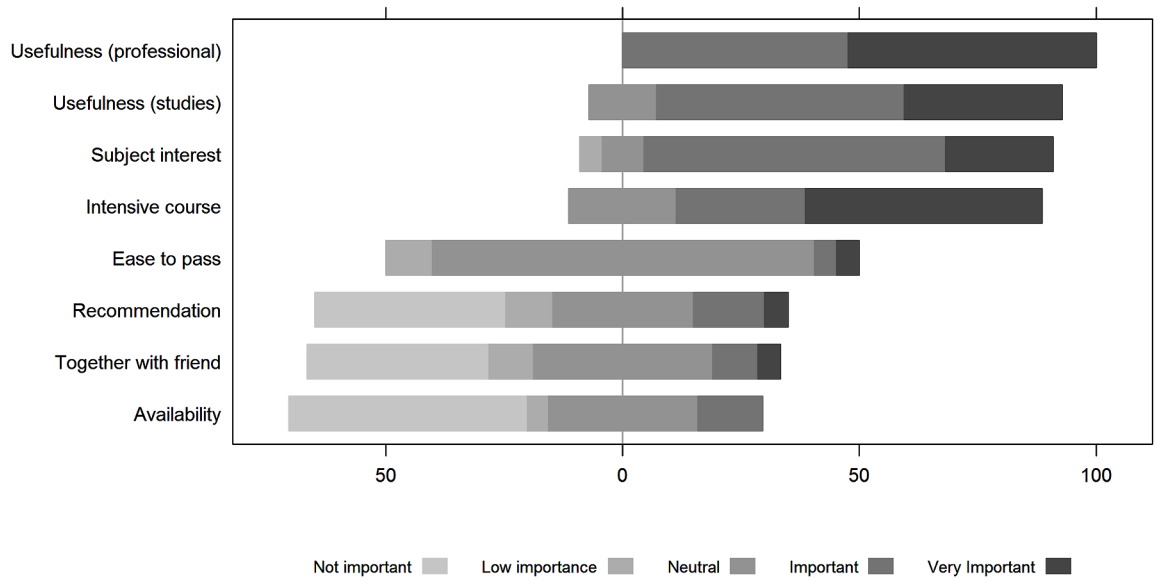


Figure 8. Motivation to attend the course (importance as a percentage)



and to a lesser extent the fact that was an intensive course. The possibility to easily get a passing grade was not a significant aspect in choosing the elective.

Perceived Knowledge Level after the Course

About the perceived level of knowledge before and after the course (Figure 9), none of the students qualified themselves as proficient, but the increase in the level of knowledge was significant, considering that all of them considered themselves novices before of the course.

The results were analyzed breaking the perceived knowledge into categories of gender, age, time enrolled and origin (Fig. 10) and the following results were observed:

Figure 9. Perceived knowledge level before and after the course (level of knowledge as a percentage)

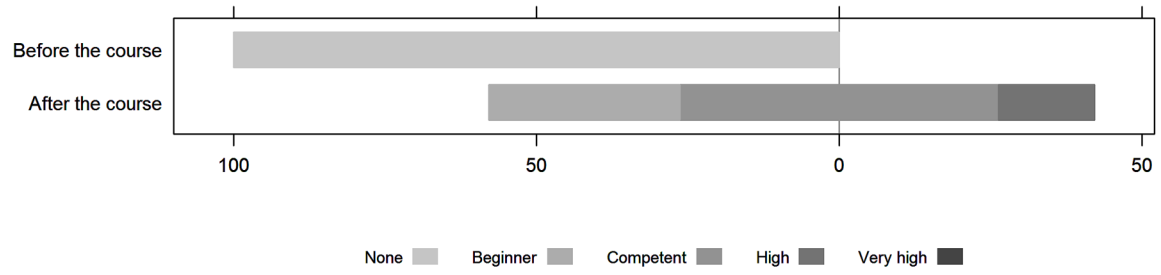
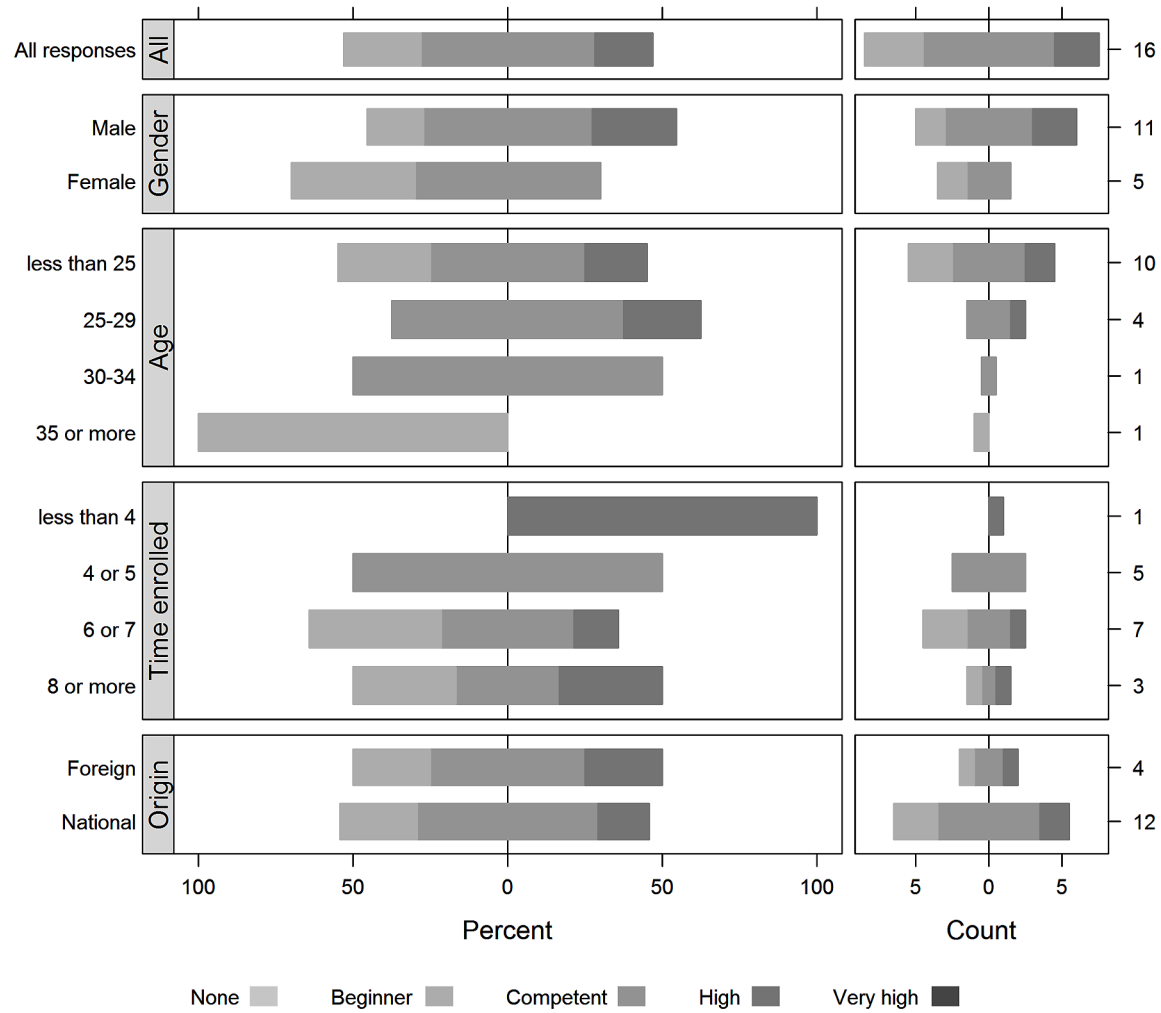


Figure 10. Perceived knowledge level after the course according to gender, age, time enrolled and origin (level of knowledge as a percentage)



- Male students perceived themselves as more capable.
- Younger students valued their knowledge higher than older ones, with a peak in the 25-29 years old tier, but the sample was too small to draw a definite conclusion.
- The time enrolled in the university did not appear to have any significant incidence.
- The origin did not appear to have any influence.

Opinion on the Development of the Course

On the development of the course, the students valued positively the learning methodology and the topics covered (Figure 11). The difficulty of the course was considered average, as well as the workload, compared to other courses.

Most Appropriate Knowledge Area and Academic Year

The authors were interested in knowing in what knowledge area GIS subjects should be taught according to the students' opinion. While the cross-disciplinary nature of the course allows it to fit into several knowledge areas, urban planning was considered as the most fitting one (Fig. 12, top).

Enabling technologies are more needed at the beginning the studies, because other subjects depend on them. Being an elective, the course can be taken anytime during the last years of the studies and could be used to test where students thought it could fit better if it was taught as a compulsory subject. The results were overwhelmingly against introducing it in the first course and favored the third (and central) year as the most appropriate (Fig. 12, bottom), which is the second year urbanism is taught.

FUTURE RESEARCH DIRECTIONS

Having established the effectiveness of the current educational methodology, refined during the previous editions, the surveys conducted opened some research directions on possible improvements. Repeat surveys conducted yearly should allow to test results of any changes introduced. More formal interviews with professionals, students and educators should also give some directions on how to improve the methodology.

Figure 11. Students' impressions on the development of the course (level of agreement as a percentage)

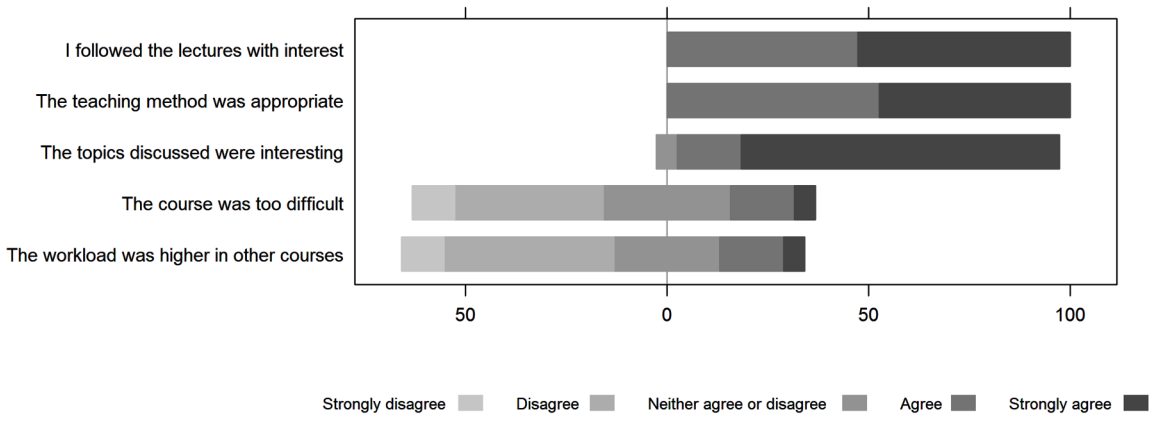
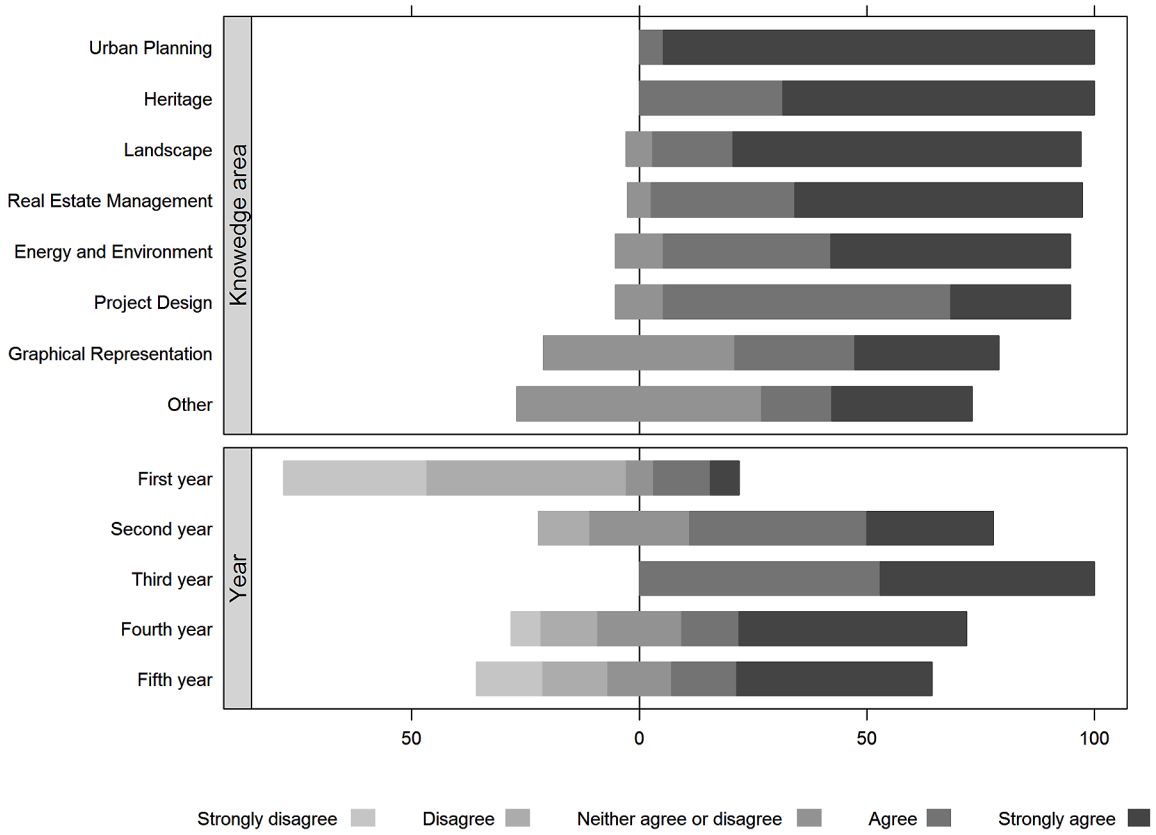


Figure 12. Most appropriate knowledge area and academic year (level of agreement as a percentage)



Improvements in the Teaching Methodology

Gamification

One approach that the authors believe should be explored is the use of gamification (Deterding, Dixon, Khaled, & Nacke, 2011; Honey & Hilton, 2011), or the use of game mechanics in non-game contexts to make the learning experience more engaging. The gamification experience should be applied initially with a low overhead on the teaching staff and the students for testing purposes.

Since current the methodology already have a two-tier approach, and challenges the students with greater skills or motivation to tackle harder exercise, the proposal is that the students that solve the more difficult problems should be awarded with badges or some other kind of virtual good. The use of high-score tables would be open to debate because the negative connotations for the students in the lower ranks.

e-Portfolios

e-Portfolios have already been used in the Barcelona School of Architecture (Franquesa, Moreno, & Elinbaum, 2013) and have proven useful in online courses (Mason, Pegler, & Weller, 2004).

The authors suggest that e-portfolios could be used to enhance the learning process in two ways:

- To enhance the sense of broadening knowledge by the student, while at the same time producing something that can be used to showcase his or her skills.

- As a tool of peer evaluation, using the e-portfolio at the end of the course to be evaluated by two or more of their fellow students, which would increase motivation and at the same time allow the students develop critical skills when evaluating the work of others using a provided rubric.

Improvements in the Teaching Materials

More Open Materials

In the survey the majority of students used Microsoft Windows but the share of Apple Mac OS was significant. The use of cross-platform software should be evaluated since the software currently used is Windows-only. The software should be free and open-source software (FOSS) and in addition the open software, students could work with open data from the OpenStreetMap project (OpenStreetMap contributors, 2015).

Modernizing Teaching Materials

In the conducted survey, the migration from the computer to mobile devices for leisure activities was noticeable. To give response to the increasing demand for learning materials suitable to be used in mobile devices, the teaching materials should be adapted taking into account the specifics of these devices (Gikas & Grant, 2013), and should also be adapted to be used in a virtual classroom in distance education (Grunwald, Ramasundaram, Bruland, & Jesseman, 2007).

In addition, multi-level teaching materials could be used to be able to teach more dynamic classes (Sajaniemi & Kuittinen, 1998) in four levels:

- Lecture notes given to the learners.
- Supplementary material presented in the lectures only.
- Personal directions that are not intended to be shown to the audience.
- Extra material that is not intended to be presented in the lectures.

In this case, the authors propose to begin with the fourth level and prepare a glossary of terms given as extra material to the students. This glossary could be in wiki form, produced by the students themselves over the years as an exercise.

Adapting to New Paradigms

Finally, the advantages of situated learning (Brown, Collins, & Duguid, 1989) could be recapped for urban planning using virtual reality (VR) or augmented reality (AR) to immerse the students in a more engaging learning experience, providing a better context for the acquired knowledge.

CONCLUSION

GIS Adoption

Informal conversations with students, professionals and lecturers, as well as the results of the survey have shed some light into the reasons why GIS applications are not more widely used in architectural studies and in the professional practice. The authors have identified the following main reasons (in no particular order), but believe that further investigation would be necessary to pinpoint the causes:

- The tools appear too complicated and mastering them seems an insurmountable task.
- The data is not formatted according to the needs of architects.
- The applications are perceived as not interoperable enough, and there is a fear of being "locked-in".

GIS packages usually adopt a modular approach, where the core general functionality is extended with modules to cater the needs of the diverse disciplines of its users. The first issue could be resolved developing extensions fulfilling the needs of architects, which could be done

by commercial vendors or by the open-source community (for example forking an existing package). Furthermore, the high cost of the licenses of commercial packages is also an important barrier because it introduces a lot of friction for early adopters to test the applications.

The second issue could be solved adapting the formats to the needs of architects. Here the main problem is not the data itself but the semantics in which it is encoded. There are some steady advances in this field (Gröger & Plümer, 2012) and in the future, semantic queries should allow GIS tools to access and integrate vast amounts of data (Li, Goodchild, & Raskin, 2012).

Finally, the third point depends on the advantages GIS can provide to architects: other classes of application have the same issues of imperfect interoperability (such as 3D packages or page layout and illustration programs) but their productivity gains and capacity to produce specific results make their use worthy for professionals and students.

Educational Approach

As the results of the survey and the strong demand in taking the course indicate, the educational approach developed have been proven successful in helping architecture students acquiring ICT skills. The main contributions of the educational approach to teach the use of GIS applications and geospatial data were:

- Introductory section intertwining theory and practice using synthetic exercises.
- Use of worked-out examples with faded guidance in the practice section.
- Using a single case of study based on a real-world project, working with real publicly available data.
- Two levels of exercises to cater the needs of students with different skills or motivation.
- Self-guided project based on PBL, developed over the length of the course and publicly discussed in the last session.

The course has matured over two decades but there is still room for improvement, as discussed in the future research directions section, which will be explored further in the next editions of the course.

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KEY TERMS AND DEFINITIONS

Cadaster: A comprehensive register of real estate properties that contains information about their ownership and their characteristics.

Case Study: A research strategy in which the focus is on a single subject.

e-Portfolio: Selection of documents in electronic form of his or her own creation that a person collects and makes available online.

Faded Guidance: A process in which the explanations in a worked-example progressively transition into less verbose demonstrations.

Gamification: The use of game mechanics in non-game contexts. The use of gamified learning activities can make the educational experience more engaging for students.

Project-Based Learning: An active-learning pedagogical approach in which students learn through problem-solving. The students work in groups and the role of the instructor is of a facilitator.

Scaffolding: A process where a teacher aids a student within his or her Zone of Proximal Development and gradually removes the aid as the student becomes more autonomous. This process can be repeated as the Zone of Proximal Development grows.

Self-Directed Discovery: A constructivist learning activity where the learner independently sets his or her own objectives.

Worked-Example: A step-by-step guide on how to solve a problem. A tutorial would be an example of a worked-out example.

Zone of Proximal Development: The zone that lies between what a learner can do unaided and what is outside the scope the learner.

Chapter 16
Active Learning using Digital Technology and Ubiquitous Information in Architectural Construction:
PBL as a Vital Methodology for Instructional Design

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ABSTRACT

In the new context of the Information Society and learning skills, architectural education through active constructive methodologies is able to form professionals capable of combining technical and aesthetic aptitudes and begin to apply to the design and building construction skills. In the discipline of Architectural Construction where contact with the professional world is inevitable. The strategic instructional design element used as main methodology the PBL. With the use of information technologies and communication, ICT and Ubiquitous information ensures the acquisition of skills and knowledge. The programming steps of PBL at the use of ICTs as tools for research-knowledge and representation -communication, achieves another educational dimension. This provides students awareness of their own learning, as also a conceptual relationship and ultimately a holistic view of architecture.

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INTRODUCTION

The new setting of higher education in the Information Society (SI) is based on the correct acquirement of skills, instead of the educational model based on the acquisition of knowledge. In the field of Engineering and Architecture (where we can also find additional studies, such as Construction Engineering or Civil Engineering), we can identify both general and specific skills related to the use and control of the Information Technologies (IT).

In architectural education, until recently, the use of IT was restricted to project implementation processes, i.e., the use of Computer Assisted Design (CAD). More recently, Building Information Modelling (BIM) applications have enabled a significant leap in the parametric design of architectural projects. Nevertheless, the IT potential for teaching and learning goes much further than the use of these tools to support educational practices and improve outcomes for understanding. The incorporation of the Technical Information and Communication Technologies (ICT) is essential to the new educational methods of the European Higher Education (EHEA). It promotes collaborative and cooperative learning, and motivates students to engage in self-learning, thus obtaining the right skills for their future careers. In other words, this approach avoids passive "lectures" that keep the teacher away from the students, and do not benefit from the digital age and new SI. Nowadays, owing to the technologically "friendly" classes, students can benefit from new learning dynamics, many of which are based on content and on-line methods (commonly referred to as e-learning).

The learning process necessary to master architecture, specifically in the construction division, should not be oblivious to this technological evolution. ICT is of great value in both educational and professional contexts, and for this reason, we consider and propose a new approach to education in architecture. This new approach includes cross-learning, problem-based learning (Font, 2004) and strategically organized projects that allow students to acquire the highest quality of skills so that they can establish their own autonomous learning (Pozo and Monereo, 1999).

THE SPANISH ARCHITECT AND COMPETENCE SKILLS

In Spain, an architect is considered a professional capable of combining technical and aesthetic skills and using those abilities for the construction of buildings or urban planning. In this sense, an architect is both an "artist" and a "builder" with a complete view of architecture that focuses its core business in the architectural design and the building work. Thus, the powers of the architect are in accordance with the provisions of European Directive 85/384 / EEC of the European Community, and the programs leading to the official qualification of an Architect. However, architectural curriculum must maintain the proper balance between theory and practice and guarantee the acquisition of specific aptitudes described following.

- The ability to develop architectural designs that satisfy both aesthetic and technical requirements.
- An adequate knowledge of the history and theories of architecture, as well as the related arts, technologies and human sciences.
- Knowledge of the fine arts as a factor likely to influence the quality of Architectural design.
- Suitable knowledge of urban design, planning and the skills involved in the planning process.
- Ability to understand the relationship between people and buildings, due to the need to harmonize these relationships depending on the needs and scale of human creations.

- Ability to understand the architectural profession and its role in society, in particular in preparing briefs that take account of social factors.
- Knowledge of the methods of investigation and preparation of the construction project.
- Knowledge of structural design problems, construction and civil engineering problems associated with building design.
- Adequate knowledge of physical problems and technologies, as well as the function of buildings, in order to provide all the elements that make them internally comfortable.
- Technical capacity to conceive buildings that meet user requirements, within the limits imposed by budgetary constraints and regulations on construction.
- Adequate knowledge of the industries, organizations, regulations and procedures involved in building projects integrating plans and planning. (Royal Decree 4/1994 of 14 January, by the official university degree in architecture and the characteristics of the curriculum leading to obtaining general guidelines state.)

The acquisition of these competences is achieved in three specific subjects, namely propaedeutic, technical and project, shown in Table 1 alongside the specific training content.

The Architecture Code, "Libro Blanco del Título de Grado en Arquitectura", covers and distinguishes two ways of learning from these materials—workshop-based and conventional.

Table 1. Thematic blocks

Thematic Block	Formative Content
Propaedeutic	Drawing, Physics, Mathematics
Technical	Construction, Structures, Installation Facilities
Project	Composition, Projects, Urban Planning

Each model can help students engage in theoretical and practical learning. The workshop is considered the most characteristic approach to teaching in the field of architecture, as it focuses on the professional experience and is the most opportune time to develop the skills and related knowledge.

Discipline of Architectural Construction is part of the technical block, as the entire curriculum is based on technical and scientific dimensions. However, considering the holistic view of architectural design, all technical disciplines are also a part of strategy and design. Construction is inseparable from the architectural design, and this integrated approach is essential to being a good builder. The professionalism resides in the technique. Knowledge of materials, technology and construction systems is essential for correctly designing and developing architectural spaces, as well as meeting environmental, programmatic and regulatory requirements imposed on a building. In this sense, it is easy to understand that 80% of the sections of the specific powers of the Architect are also found in the objectives of the discipline of Architectural Construction. Following these concerns, teaching Construction cannot rely on a conventional learning methodology without considering the parameters of architectural context. Thus, learning meaningful construction is facilitated through participatory workshops, where students are provided with tools to create their own procedures needed to resolve any issues and thus learn to be autonomous. In this constructivist view, teaching is perceived as dynamic, participative and interactive (Piaget and Vygotsky, 1977, 1979). Also taking into account the new scenario of the information society, SI, the rapid evolution and daily development of new technologies and the constantly changing demands of the construction, the university learning must incorporate the techniques of information and communication ICT. Both techniques can be applied as tools to update knowledge and not be isolated in an outdated professional framework.

Tools have the capacity to transform and improve education through psycho-educational and didactic approaches.

In La Salle School of Architecture, this line of thought is evident in the instructional methodology of the discipline of Architectural Construction, which is strategically designed to ensure that the student knows how to evoke, select and use prior knowledge. This approach also allows learners to develop processes, engage in self-regulated learning, transfer and test the functionality of information, with the help of ICT. Ultimately, this promotes active thinking processes of critical higher demand. This methodology combines learning and discovery format in theoretical classrooms and problem-based PBL, with a draft of professional connotation through classroom workshops. In this view of PBL, learning is an active process that takes place in a bounded professional context. Additionally, education is centered on students learning to think and act for themselves, taking into consideration the characteristics and the context of the activity. Therefore, it becomes a valuable learning methodology to suit all demands of acquiring academic and professional competence.

Competencies in the Information Society

In the new social, economic, political and cultural scene of the SI, the education and training in ICT is a valuable way to acquire and produce knowledge. In a world where distances shrink, borders disappear and big problems are shared, the growing mobility of people and increased heterogeneity of communities creates the need to work together to solve even bigger common problems. Education is forced to deal with this situation and the society is increasingly demanding inclusive schools, which are intended to meet the diverse educational needs of students. The non-formal and informal learning (taking advantage of the opportunities offered by modern society for education and training of a wide range of individuals) and collaborative and cooperative learning (benefitting from the knowledge and skills of the different members of a group to meet common objectives) have thus emerged as new ways of providing education (Coll-Monereo, 2011). According to the European Commission, in the near future, when looking for employment, people will rely more on their qualifications and skills, as the security of a permanent job will soon be a thing of the past. According DeSeCo Competencies—Definition and Selection of OECD project, core competencies can be grouped into three categories (Rychen and Salganik, 2001, 2003), shown in Table 2.

Generic and Specific Skills in Architecture

Fernández Alba (1975), began to question the educational model that architects needed to follow in Spain. After a series of pilot experiences in different courses of the Chair of Composition at the School of Architecture of Madrid and "Ideology and architectural education in contemporary Spain", he proposed a new educational model. This educational model was based on student consciousness and responsibility in learning, which defines the objectives and techniques described in Table 3.

In 2006, The European Network of Heads of Architecture (ENHSA) identified the most important skills (generic and specific) in the learning

Table 2. Competencies most valued by the OECD in the DeSeCo project

1	Ability to act autonomously (including capabilities to form and implement life plans and personal projects, to defend and assert one's rights, interests, limits and needs, and act taking into account the broader context or framework)
2	Ability to interact in socially heterogeneous groups (including the capacities to cooperate, relate well to others and control and resolve conflicts)
3	Ability to use resources and tools interactively (including capabilities of using data flexibly, languages and texts, and especially digital media).

Table 3. Objectives and pedagogical techniques of architecture student

Objectives	
1	Students must be responsible for their own learning
2	Organisation of learning should facilitate acquisition of skills for further learning, rather than merely focusing on acquisition of knowledge
3	Development of social and personal skills is as important as acquisition of knowledge
4	Evaluation of the work should be the responsibility of both the teacher and the student
5	Students' abilities to plan, implement and evaluate their own work must be accepted as legitimate by the teacher
Pedagogical Techniques	
1	Deepen and increase knowledge to guide students
2	Focusing on the domain of the sources and methods of knowledge, rather than concrete knowledge
3	Rather than the work taught in class, focus is on the definition of the objectives, the self-motivation and evaluation of the work.
4	Adoption of new sources of existing community-based learning and various media

process implicit in the architecture course via a questionnaire completed by professors teaching in several eminent European universities (see Table 4).

The European directive on the Higher Education Area (EHEA) has transitioned from a model based on a teaching focusing on the content towards a model based on acquisition of skills that will facilitate the integration into the professional world and the changing market needs. The skills taught as a part of the Architectural Construction discipline, at the School of Architecture of Barcelona, La Salle, ETSALS, are defined in Table 5.

TEACHING AND LEARNING OF ARCHITECTURAL CONSTRUCTION IN THE INFORMATION SOCIETY

The new approach to teaching and learning, focused on the acquisition of skills, and the arrival of ICT, has changed the role of students and teachers, the forms of interaction, the space-time coordinates and access to resources. Therefore, it has introduced modifications to all the instructional methodologies.

ICT provides new dimensions of learning, which are not just tools to enhance and facilitate the traditional teaching, but also include the acquirement of skills. ICT skills provide analysis capabilities and critical reflection while promoting awareness of the need to develop and maintain the e-portfolio. Therefore, this approach is well programmed in terms of psychological ICT and can promote meta-reflexive and metacognitive learning.

Table 4. Skills most valued by teachers and architecture professionals

List of the 5 Most Valuable Generic Skills	
1	Computer skills, including the ability to critically use the Internet as a communication media and information source
2	Ability to learn
3	Ability to synthesise
4	Personal and social skills in oral expression and communication
5	Ability to apply knowledge to practice
List of 5 Specific Skills Most Valued by the Professional Architects	
1	Understanding of the relationship between people and buildings, as well as between spaces and their environment. Appreciating the need to respect the buildings and the surrounding spaces, according to the necessities imposed by the environment.
2	Knowledge of contemporary and historical works that have met the highest standards in architecture.
3	Appropriate knowledge of history and theories of architecture, as well as arts, technologies and human sciences.
4	Understanding of structural problems, structural design and engineering associated with the design of buildings.

Table 5. Architectural construction skills ETSALS

General Skills	Specific Skills
Instrumental Skills	**Group A: Skills**
IS1. Analysis and synthesis skills	A23. Conservation of building technology
Interpersonal Skills	
	A24. Conservation of finished buildings
	A25. Rehabilitation of building technology
IT2. Team work	A26. Rehabilitation of finished buildings
IT9. Environmental consciousness	A30. Construction law management
	A32. Building assessment
Systematic Skills	
CS1. Ability to apply knowledge to practice	**Group B: Knowledge**
	B14. Ecology and sustainability
	B25. Building materials
	B26. Conventional construction systems
	B27. Industrial building systems

In ETSALS Construction, we can define the relationship of the didactic triangle with ICT based on three categories, as tools that facilitate access to information, such as software tools and communication systems (see Figure 1).

The strategy of combining significant learning methodologies (reception and discovery) with problem-based learning (PBL) makes the relationship among the elements of interactive didactic triangle (teacher, student and content) and their participation in ICT more active and valued.

The presently utilized didactic triangle follows the TPACK model (Technological Pedagogical Content Knowledge, Koehler & Mishra, 2009), which extends Shulman's idea of Pedagogical Content Knowledge (Shulman, 1986), and describes how an activity that requires technology must be integrated adequately into the classroom by connecting three knowledge fields—curricular, pedagogic and technologic (see Figure 2).

Figure 1. The ICT and its relationship with the didactic triangle

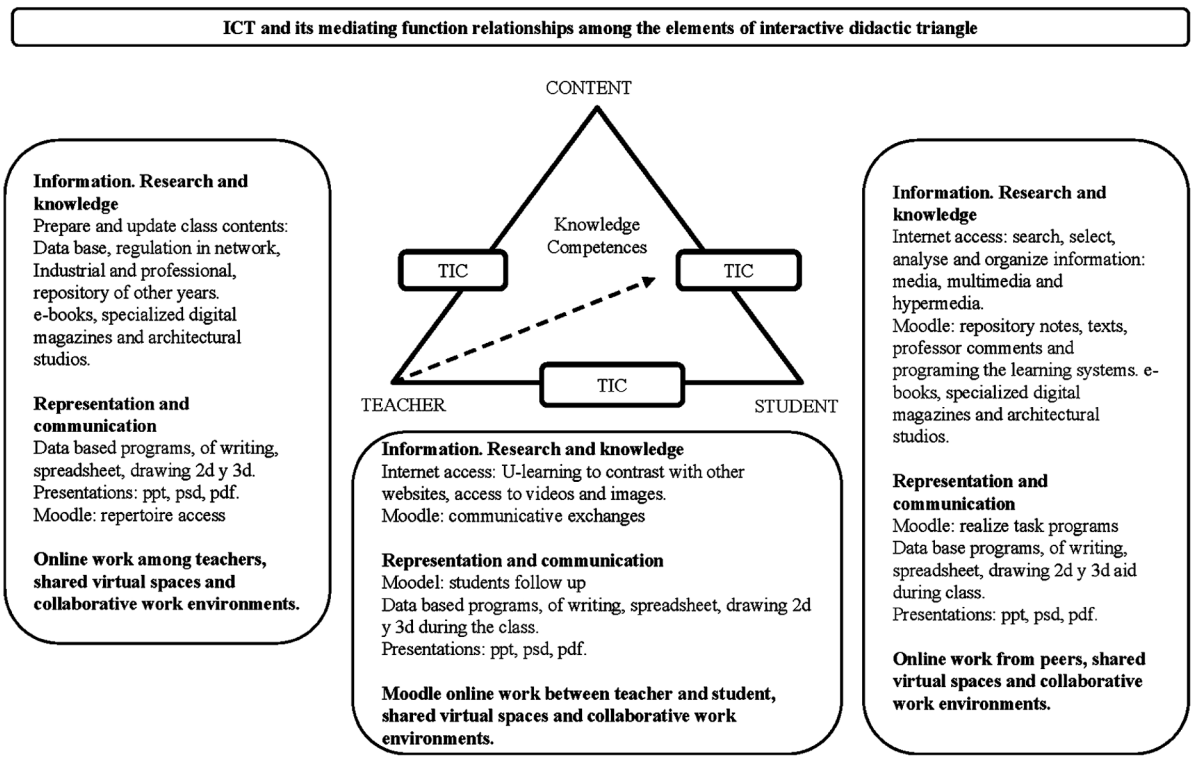

Figure 2. The TPACK framework and its knowledge components
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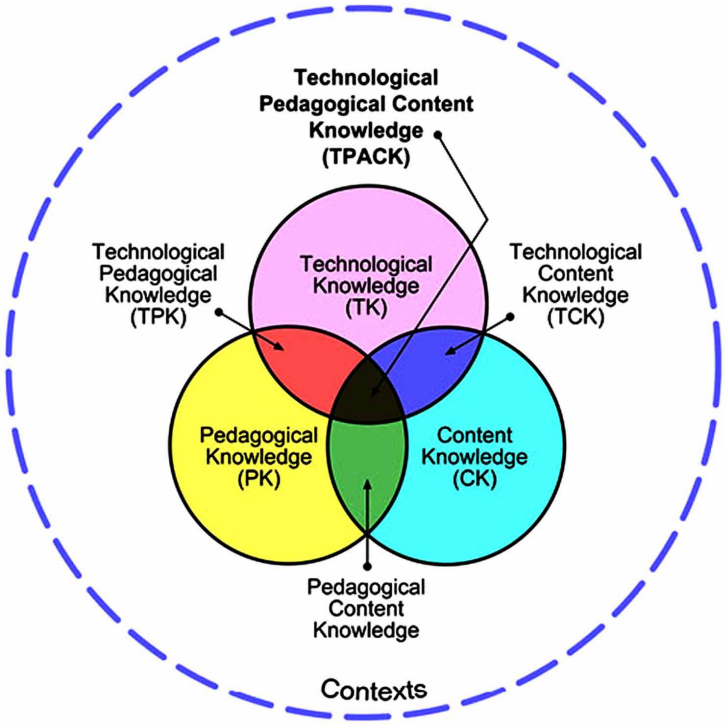


The model is based on a current teaching context characterized by a high degree of complexity and great dynamism, making the integration of the following multiple knowledge components necessary:

- The curriculum, which can be understood as the theme or content selected for technological implementation.
- The pedagogy, which includes the activities and their delivery, the teacher's and students' roles and the evaluation system.
- The technical component, including the training necessary for using the technological resources, the selection criteria for the technological devices and the proposed uses for the technology.

Therefore, to obtain good results in the learning process, it is necessary to develop a solid understanding the students' profiles and the role of the professor. In addition, having a clear awareness of the objectives, knowledge of the subject area and the skills that are going to be obtained helps determine the teaching methods that are going to be applied.

Student Profile

Modern students are Digital Natives (Prensky, 2004) and are conducting large part of their lives on line (this, developing an e-life identity). Therefore, just as cyberspace is a constituent part of everyday life, ICT tools are part of their modus vivendi, and the digital network is:

- How they communicate, meet, interact and socialize with others,
- The way they search, create, share, exchange and collect information
- How they cooperate, learn and evaluate their achievements, analyze problems and publicize their ideas and conclusions.

Consequently, any learning process that does not resemble students' way of life can cause boredom and absenteeism in the classroom. Incorporating ICT into learning strategies requires understanding of the use and management of electronic communication and information sharing. According Monereo (2011), the natives (in respect to the practices relating the management of information that helps transform it into knowledge) prefer to receive original information and select what interests them, using rather idiosyncratic criteria. Their search skills are unsophisticated and are typically developed through the understanding of the domain of discipline. In contrast, the digital natives show strong competition in sharing information with others to build a common product. For them, competence does not equate to possession of knowledge, but rather implies being able to locate and share it.

Teacher's Role

In the process of skill acquisition, the role of the teacher changes as the learning model shifts its focus from content, curriculum, and knowledge to information acquisition and processing. The teacher is no longer a mere transmitter of information and the central protagonist of exchanges between the students. Now, the teacher is a manager of the available resources, tutor and consultant in resolving doubts, as well as a counsellor and guide in conducting projects and a mediator in debates and discussions. The teacher in this model shares responsibility as the guardian of the students' own curriculum.

In the specific case of Construction, the teacher is an active professional architect who has direct experience in the discipline and a holistic approach to architecture. Therefore, he/she recognizes the importance of both the curriculum area in class and the work experience on site. Professor of Construction sets the learning targets, aiming to help the students acquire knowledge in the different units of learning, linking newly acquired skills to those previously obtained, helping transfer their relevance to the professional future.

Skills to Acquire

The materialization of specific skills in the academic portfolio is divided into three courses. These basic concepts and requirements will be used later on in higher courses applied in Executive Projects.

Construction C-I: The construction begins from two thematic areas: matter and order. The first includes the subject as a physical entity, such as building materials and as expressive material of architecture. The second section analyses the demands of support and comfort (thermal envelope, noise, etc.) and organizational forms to meet these demands. Structural and cladding systems on premise equipment and constructive order are studied, with a particular emphasis on the environmental aspects of each project decision.

Construction C-II: The course examines in depth the systems of heavy / wet construction support and comfort of buildings. In support systems, knowledge of soil, foundations, wall and frame structures, both unidirectional and bidirectional is gained. In comfort systems, vertical envelope, facades, horizontal, decks and the perimeter in contact with the ground are studied.

Construction C-III: The course examines in depth the dry construction systems support,

comfort of buildings and interior systems. Support systems of the knowledge of fuzzy structures are also studied, while vertical envelope, facades and horizontal elements, the deck and inside divisions are explored in comfort systems.

Both C-II and C-III Constructions study, analyze and investigate all existing systems, according to their technological realization and component materials, construction process and architectural features. At present, this syllabus is not closed because technological advances in new materials and construction systems are constantly emerging and are added as appropriate. The global research into new construction guidelines, requirements and regulations is utilized to update the content in a timely manner.

However, in order to consider an open curriculum, one has to be aware of the Information Society, and introduce students to the online learning skills and use of ICT. This should teach students to properly manage ICT, and discretize information, in order to be able to:

- Search and select information, to distinguish the trivial from the important,
- Understand the essence of the information, infer consequences and conclusions,
- Read different languages (multimedia and hypermedia),
- Use various information databases to meet their needs,
- Manage, store and present information organized according to different purposes.

Computers are already ubiquitous, and it can be expected that, in the near future, they are likely to become invisible to our everyday landscape as an element thereof (Weiser, 1991). This makes learning the proper management of ICT and ubiquitous learning even more imperative. In terms of general student competencies, the capacity for analysis and synthesis, teamwork, environmental sensitivity and ability to apply knowledge to practice are considered essential. The recognition of the need to acquire these skills is evident in all practices realized. They are also supported by the participatory theory, and ultimately lead to the strategic design of instructional discipline.

STRATEGIC INSTRUCTIONAL DESIGN. THE PBL VERTEBRATE OF SKILLS ABILITIES AND KNOWLEDGE

The strategic design relates to two different, yet interrelated, learning models. The first is a learning model based on a constructive theoretical and participative format, where basic concepts are learned and reflections on knowledge facilitated. Short seminars are conducted; focusing on different general skills, always developed using ICT. The second model is problem-based model of learning, PBL, which can be viewed as a vertebrate of skills that reinforces skill acquisition. Through the format of workshops using all available ICT tools, it is intended to solve an executive project from a constructed building, just like a professional job.

Participative Theory and Seminars

The methodology used in learning theoretical concepts is significant, as this is where the new information relates to the knowledge that students have already acquired in previous courses, allowing them to explore concepts while providing more tools for self-learning. The teacher's role is that of a tutor and manager of knowledge through participatory lectures and exercises, along with "seminars" intended on obtaining skills and deepen the curriculum.

The theory classes are lectures and discussions, since the student has the notes in advance and the teacher focuses on relevant questions and points to consider and enhance. To maintain participation and student attention active, tests are conducted.

These tests are administered through the network via Moodle, and the students are required to complete them on-line prior to the class, or directly in class through a dialogue (strategically incorporated into the lectures, with questions pertaining to certain slides, photographs or videos). These tests allow a continuous evaluation and therefore track the students' progress.

All notes follow the same format and script, enabling students to relate knowledge and follow demands, strategies and solutions through repetition and assimilation (Figure 3).

The classes are also designed to keep the same focus, concentrating on a list of requirements to be met by all building systems (to the extent of its role), which will facilitate subsequent decision-making in practice and assessment of the resulting solutions (Figure 4).

Taking a holistic view on architecture provides allows designing the requirements of support and comfort in the system, focusing on their relationships.

Support requirements:

- Resistance,
- Stability,
- Compatibility,
- Durability,
- Fire resistance.

Comfort requirements:

- Thermal control,
- Water tightness,
- Hygrometric control,
- Light control,
- Noise Control.

In all constructive solutions that arise during the course, the students will have to justify the suitability requirements.

Alternating this type of classes with more conceptual classes that are taught by a professional experienced teacher in construction management

Figure 3. Key guidelines for all lectures that have a common format

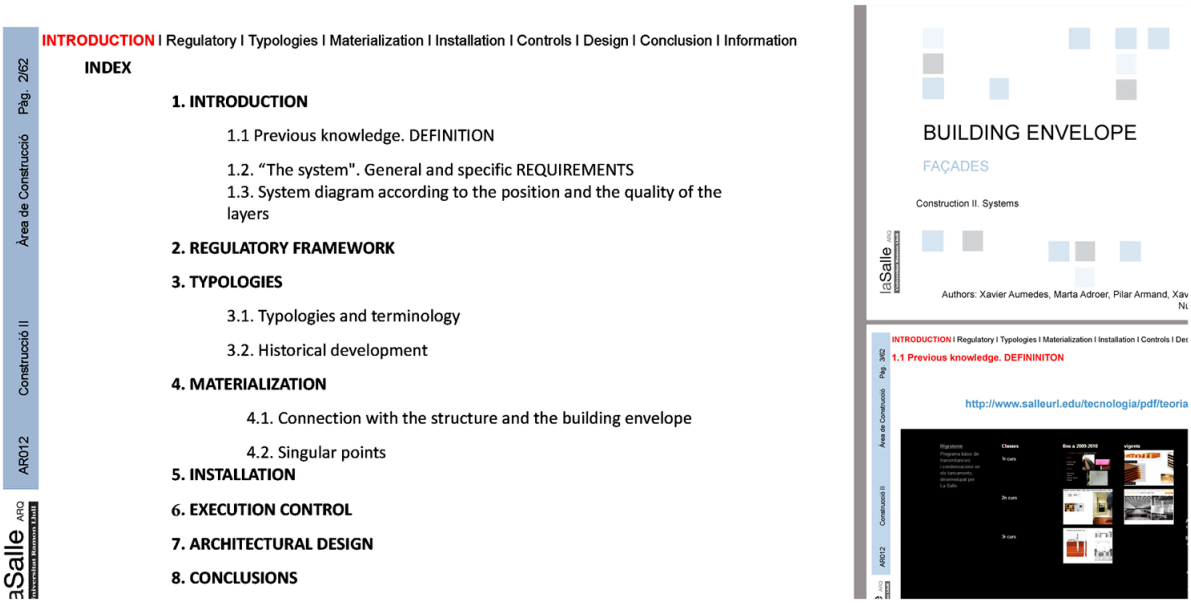
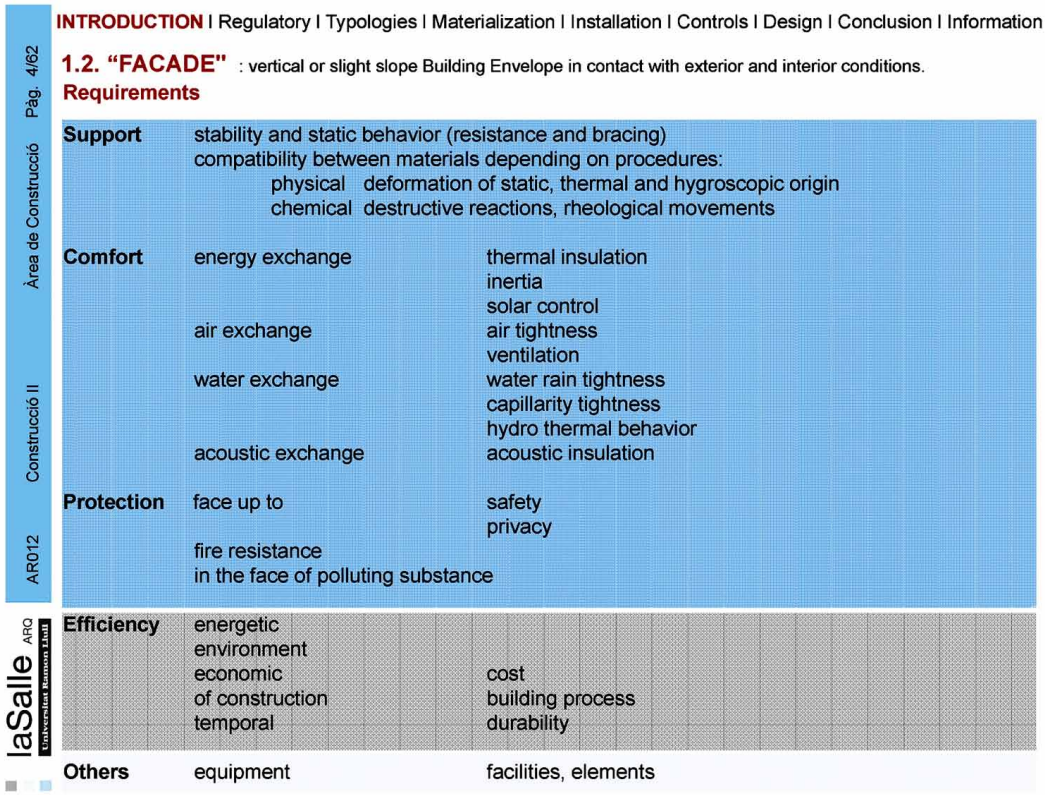


Figure 4. Checklist of constructive requirements



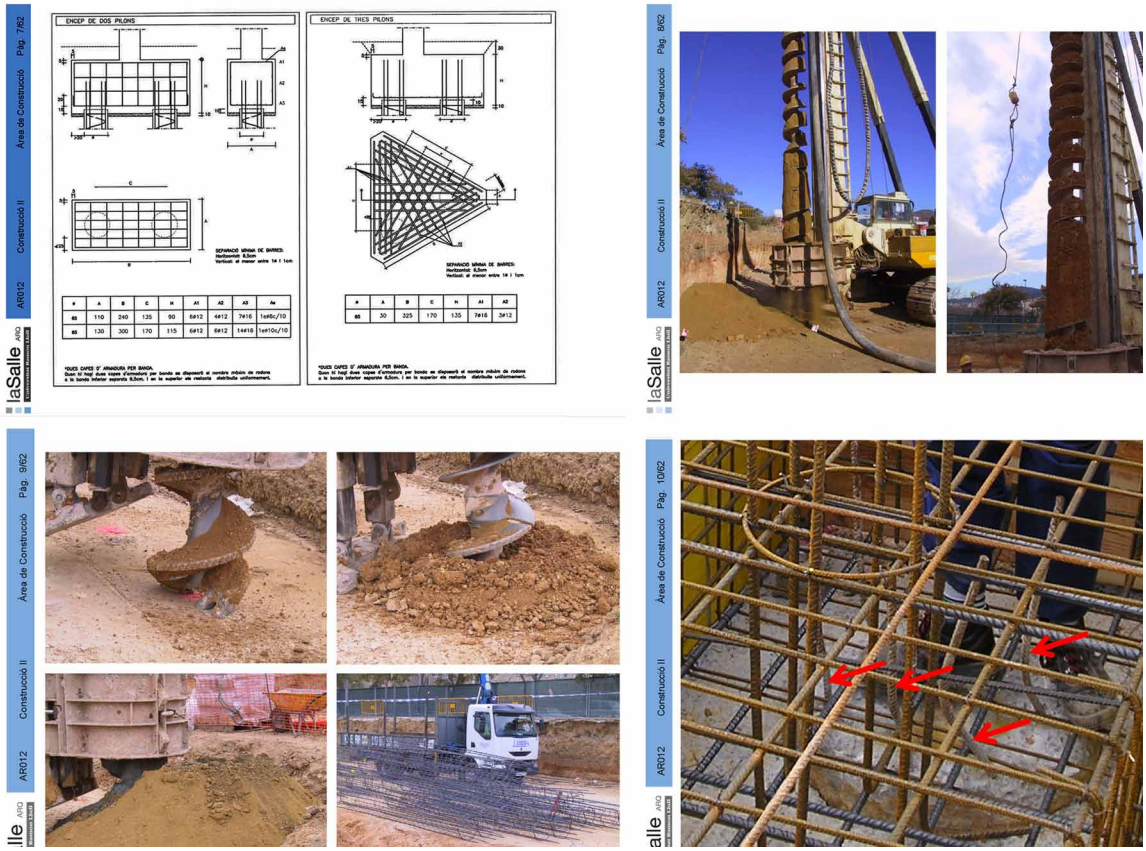
allows the students to discuss pre-focused curricular matters. Through photographs and videos, specific cases are explored in more depth, linking concepts, presenting real and unforeseen situations and discussing the solutions applied.

The seminar exercises are meta-reflexive and metacognitive punctual instructions. The acquisition of skills and the awareness of the "why" of the work, its projection into the future and students' professional self are the main goal of this initiative. For this reason, the seminars are conducted in two stages: the solution and the self-correction. In the first seminar, the exercise is introduced to the class and the students have to solve it outside the classroom, posting the solution in Moodle within the predefined timeframe. In the second seminar, the teacher provides the solution and the students are required to provide corrections. This approach promotes self-analysis and reflection on the suitability of the solution and helps the students evaluate their work. This self-assessment is performed by completing rubrics of a table, where students have to reflect and be critical about the different skills utilized and become aware of the utility of the seminar for their professional future.

Figure 6. presents an example of a seminar completed by a student, with the self-evaluation and correction shown in green color. As can be seen, the proportion of time and effort dedicated to self-learning and consolidation of knowledge is the same as the time dedicated to resolving the exercise alone.

Each seminar focuses on different skills, which can be both general and specific, and each requires different IT tools and further reading. Generic competencies are developed by the students, where most emphasis is given to:

Figure 5. Professional experience classes

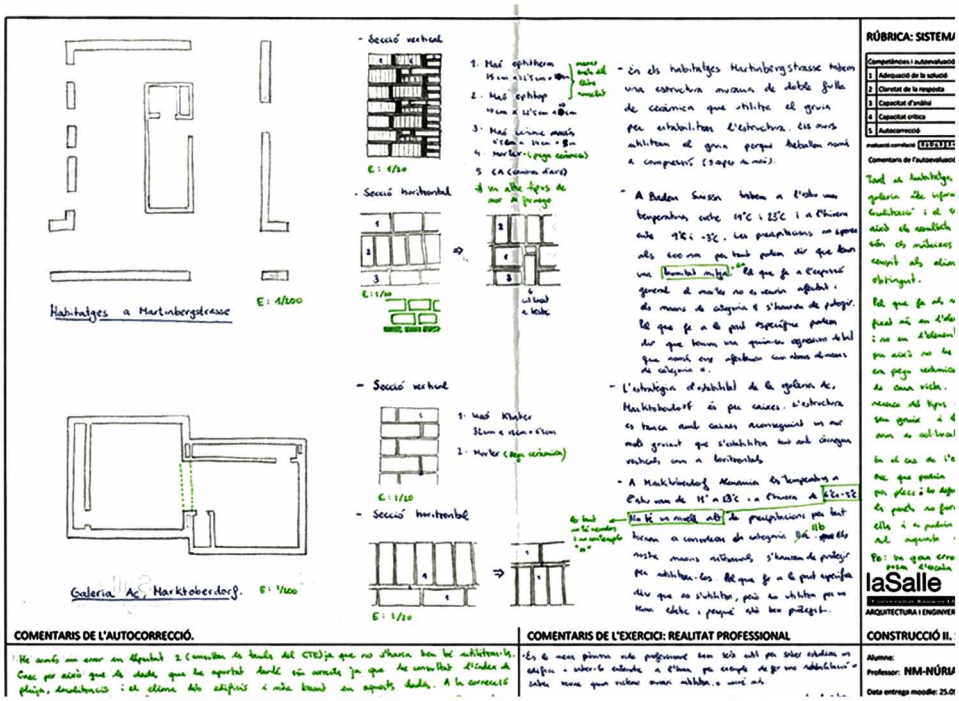


- **Instrumental:** Capacity for analysis and synthesis (G1), information management (G6), written and graphic communication (G3), knowledge related to the field of study (G5), problem solving (G7) and decision-making (G8).
- **Personal:** Critical reasoning (G14) and ethical commitment (G15).
- **Systemic:** Autonomous learning (G16), adaptation to new situations (G17), motivation for quality (G22), sensitivity to environmental issues (G23).
- Graphical Skills (G25), imagination (G26), spatial vision (G28), mechanical intuition (G29), manual ability (G31) and historical culture (G32).

Figure 7 depicts different seminars where the students are required to do the following:

- Relate the construction system of a building to theoretical typologies outlined in class (G1), (G6), (G14), (G25), (G28), (G29) and (G32).
- Question a constructive solution in relation to legislation, situation, certain environmental parameters, implementation process and design strategy (G1), (G6), (G5), (G7), (G8), (G14), (G15), (G16), (G17), (G23), (G26), (G28), (G29) and (G32).
- Search and synthesize information from a construction system based on official documents and websites of retailers (G1),

Figure 6. Example of seminar with self-evaluation and correction



(G6), (G5), (G8), (G14), (G16), (G17) and (G28).

- Describe the elements of a system and identify an example, move the information graphically in 2D and 3D by hand and using IT (G3), (G5), (G25), (G26), (G28), (G29) and (G31).
- Relate concepts with photographs of execution (G1), (G6), (G5), (G8), (G14), (G17), (G26)and (G28).
- Manage rules and apply them to a case study (G1), (G6), (G5), (G7), (G8), (G14), (G15) and (G16).

The participatory and significant theories pertaining to generic and specific skills are worked on separately. The student does not have a clear view of the whole curriculum until global assessment tests or transverse exercises are completed. The assimilation and consolidation is performed when the theory applies to the practice of PBL.

PBL: Project's Program Based Learning, P's PBL

Barrows (1986) defined PBL as a student-centered pedagogy that enables students to learn about a subject through the experience of problem solving. Therefore, PBL is an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem. The PBL incorporated into contemporary architecture is based on the realization of a professional executive project of a well-known architect's building of the mid-SXX, with the difficulty of having to apply current technical regulations and reinterpreting the existing solution, while retaining aesthetics and composition of the constructed building.

When this approach is applied, the problem is always flexible and all solutions that are correctly justified are correct. For this reason, students must

Figure 7. Example of seminars

be able to think, apply, investigate and transform knowledge to solve project-related problems. Dealing with a complex problem that is actually composed of many problems requires ability to divide work into blocks, as shown in Table 6.

In phases A and B, the student is introduced to the problem. In phase A, the building that is going to be worked on is presented, introducing context of the architect and architecture, analyzing both by observing the building and searching information pertaining to the location. Figure 8 provides photographs and original drawings of the building studied, created by the student, in this case the Guzman home from the architect Alejandro de la Sota.

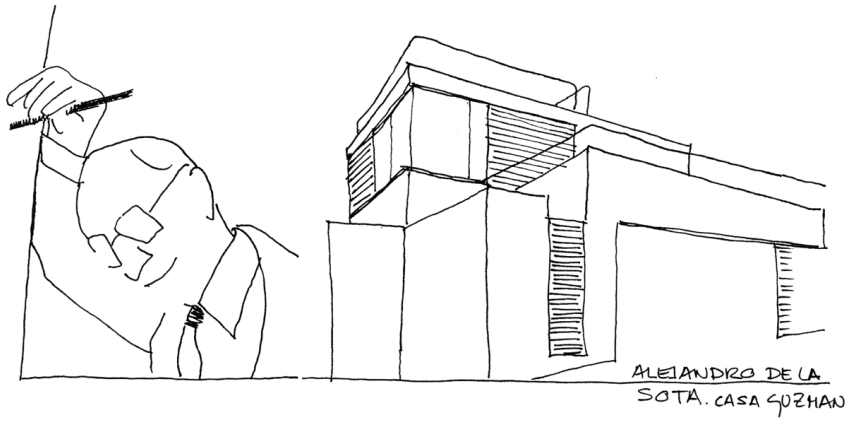
In phase B, students' knowledge is probed to make them reflect on the complex problems. The overall objective is to help the students understand the scope of the problem. Addressing it in an orderly and themed way and creating clear guidelines to follow allows a clear conceptual map to be developed, facilitating problem understanding and the way to approach the solution.

In these early stages, both in the classroom and at home, students must seek information repositories pertaining to the discipline area, both through the web www.salleurl.edu/tecnologia or Moodle. This helps relate the various curricular subjects with the division of blocks and allows students to start studying independently, thus

Table 6. Phases of the P's PBL in architectural construction

Strategic Instructional Design PPBL			
Stage	**Steps**	**Objective**	**Strategy**
A	-	Introduction to P-BL complex: "What do I know"	First statement of the case and problem analysis.
B	-	Divide the problem by blocks: "What do I know"	Identify area of knowledge, explain, ANALYSE- Understanding REQUIREMENTS
C.1	1	Increase in information: "What do I need to know "	More accurate approximation of the reality behind the problem. Explore all possible solutions.
	2	Hypothetic work based on systems. Open problem.	Apply knowledge to the detected hypothesis construction systems. Detect problems and advantages. Increase "What do I need to know"
	3	Choosing propose to develop reasonably.	Review of hypotheses based on the REQUIREMENTS.
	4	Analyze "pitfalls" of the hypothesis	Locate the singularities of the system applied to the case. Work on possible solutions. Revise based on the requirements. Increase "What do I need to know." Relate to the thematic block
	5	Formulate Proposed solution C STEP (STEP Revision 3 and 4)	Change / reaffirm the concreteness of the problem based on STEP 3 And 4 1/100 scale solution
	6	Revision PBL1	Check consistency with the project and with requirements
2…x-1			
C. x	1_4	IDEM (change the problem scale)	IDEM
	5	Formulate Proposed solution C STEP (STEP Revision 3 and 4)	Change the realization of the problem / solution 1/100 reaffirm the solution level. Correlate with Block 1
	6	Propose Revision	Check the work, considering the final coherence between Block 1 and Block 2
D	-	Propose Solution Complex Problem	Results presentation
E	-	Evaluation	Qualitative revision

Figure 8. Stage A



advancing knowledge. Phase C is the core of PBL. Here, students have to identify and articulate the demands of the problem, being aware that their formulation depends on a solution of another. After identifying the issue and setting demands, the student has to analyze, investigate, synthesize documents, reflect and be critical. He/she must approach the problem-solving by trial and error to provide the most appropriate solution. The problem is addressed at various levels and explores curricular concepts addressed both in the classroom and independently at home. The teacher has a complete control of every problem and sets the time required for each. However, the teacher does not have the final result, but advances and researches with students for possible solutions (Cortaz, Guerrero and Vergara, 2001), showing different ways to investigate.

These guidelines lead to developed work and are associated with several objectives. The teacher has pre-designed strategies and certain working tools to facilitate the approach to the objectives. However, this is only a pre-design proposal, as both the strategies and the tools can be modified by the teacher on the basis of singularities, reactions and contributions of the class. The overall condition of the architectural discipline is directly reflected in the posing of the PBL. In the sequence of blocks, as well as in the sequence of steps within the block, the change of scale is needed to reach final proposals that address the complexity of the architectural problem without simplifications or inaccuracies. Figure 9 shows a blackboard sketching of a debate conducted in class. In step 1, it is evident how the proposal moved by hand and on paper. On the other hand, in step 2, the students identify the difficulties and advantages of the first approach to the problem and start discussing "what I need to know." With tablets and cell phones, students have access to course notes and can compare information ubiquitously.

To test the hypothesis based on the requirements, in step 3, a real model is generated. This provides insight and allows ascertaining whether the requirements are met. This leads into step 4, where the students are required to progress towards more detailed drawings in 2D and display 1/200 scale 3D singular points, as shown in Figure 10 and 11.

Once the solution is defined, step 5 can commence. Here, the construction detail takes place, changing the specification of the problem, reaffirming the resolution scale 1 /50-20; -1 /10-5 specifying materials with explanatory legends, where not only the material is identified, but also actions, their functions and requirements.

Having discussed the issue against the requirements, working at different scales (step 6) allows

Figure 9. Step 1 and 2

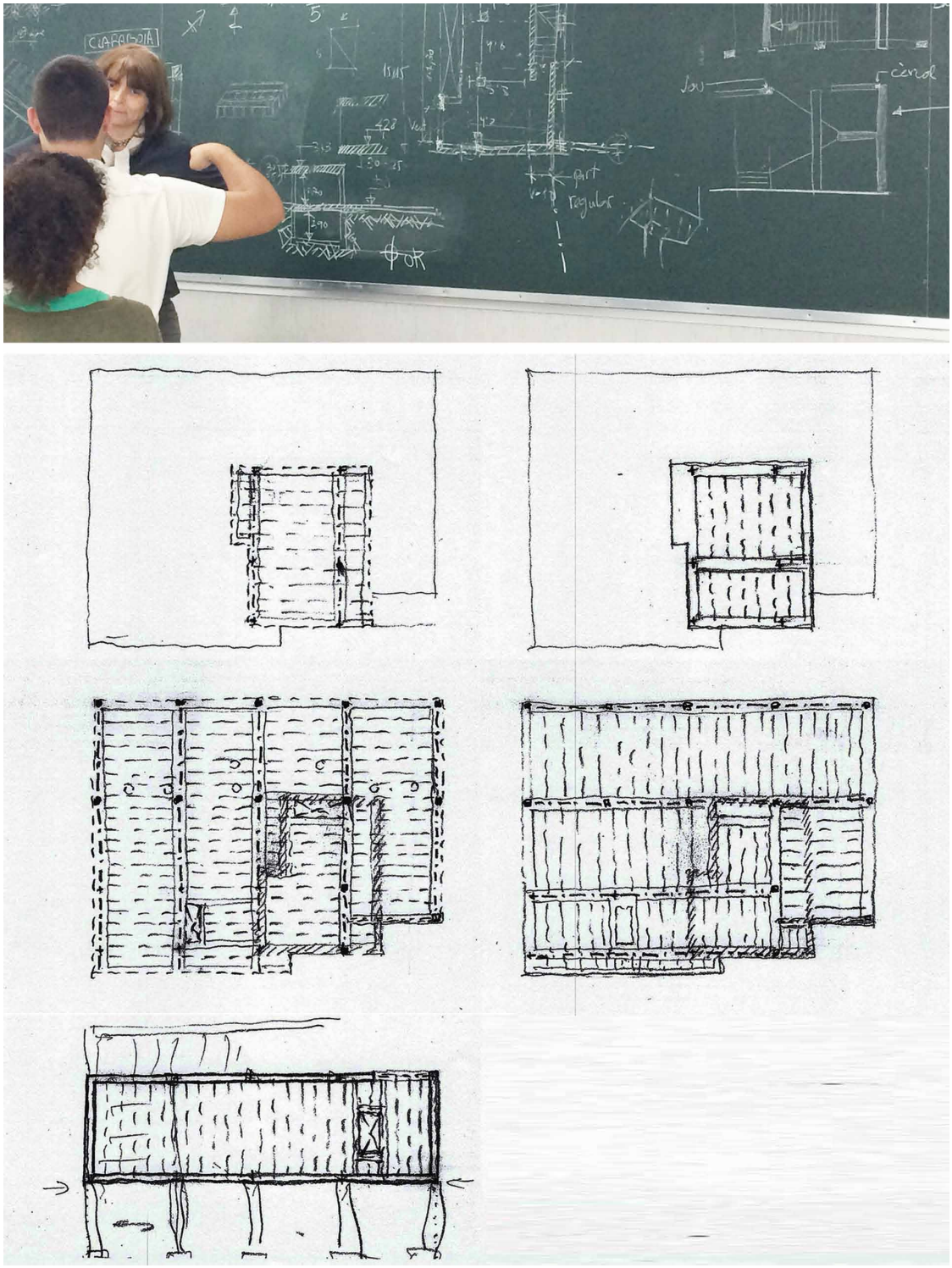
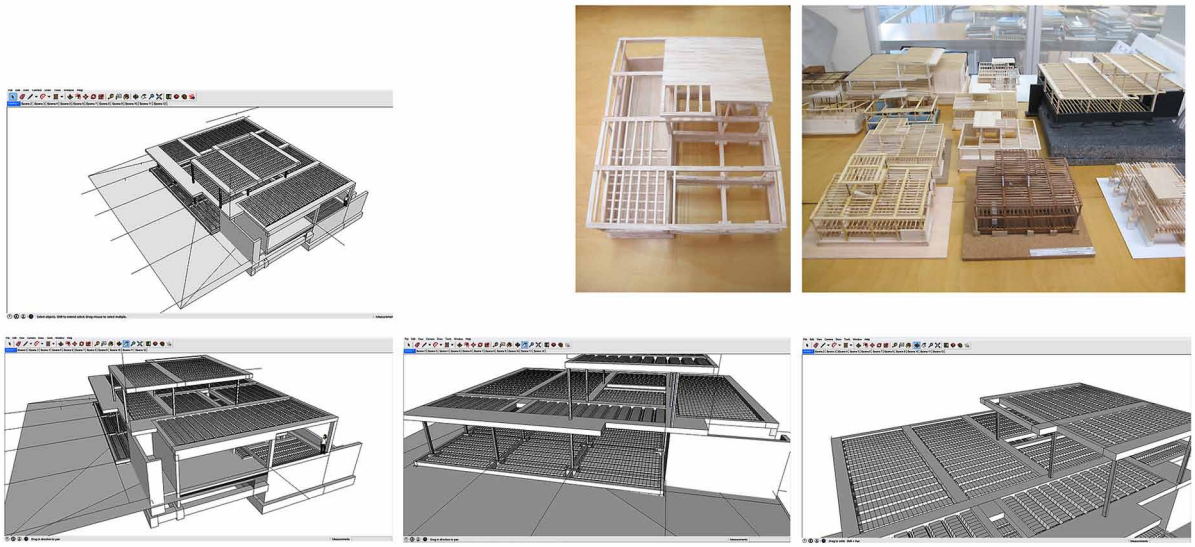


Figure 10. Step 3 and 4 - 3D works



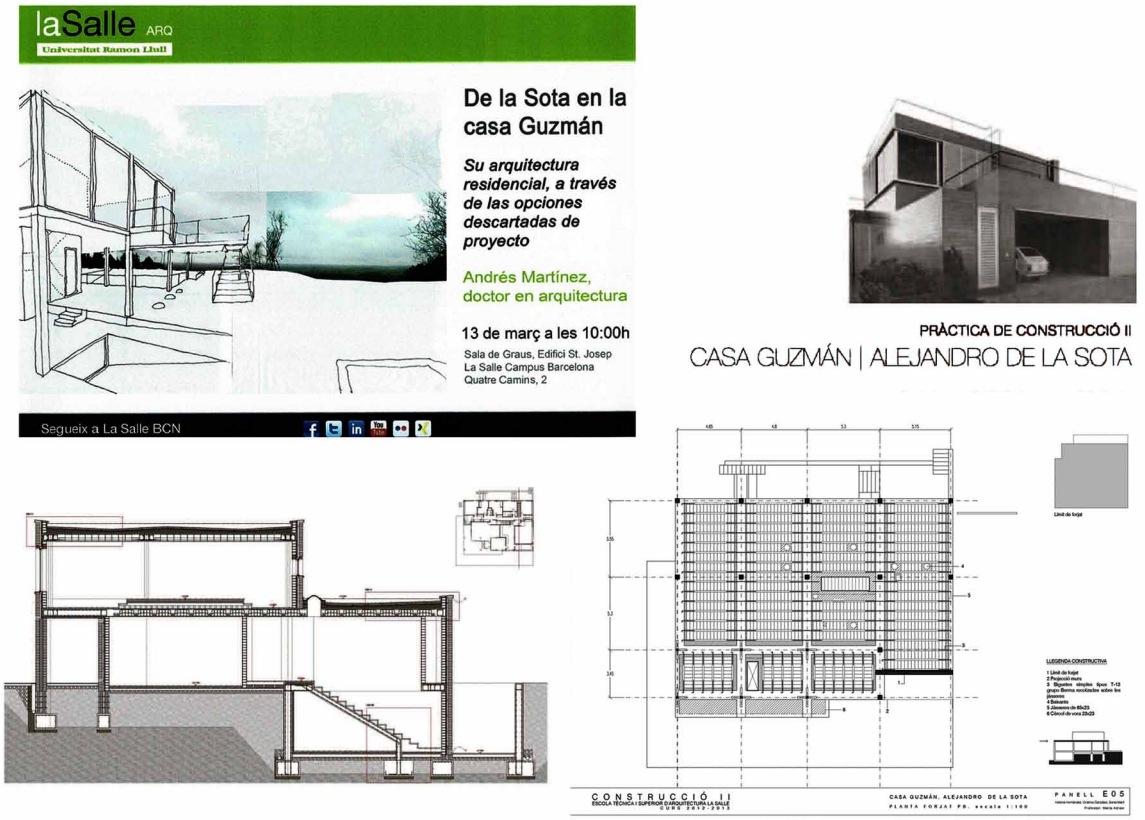
students to assess the solution throughout the set to 1/100 scale. Extensive requirements are reviewed to verify that all the premises are true (see examples presented in table)

The last step in each block is intended to be reviewed and modified against the proposed solution within the block, if necessary. Similarly, this facilitates assessment of the consistency of the sum of the various blocks with a complex view of the problem as a whole. Although the work is conducted in teams composed of three students, the problems are addressed in class, through open discussions, using computers or among individuals comprising different teams. Depending on the objectives of the block, these different approaches are chosen in order to promote teamwork and collaboration skills, as well as enhance motivation for self-learning. In this instruction, the faculty is a cognitive mediator because students are not given a unique solution and a unique way of thinking. Students take charge of their own learning and self-regulate. They are also made aware that learning is social and receptive to the ideas of others. Thus, they need to be open to proposals and reconcile conflicting or opposing arguments (Bartley, 2007).

All tools utilized are also modulated at different scales. The investigation objectives can be global and are thus assessed through questionnaires, where the problem is specific but the field to which it pertains is much more complex Thus; work is based on keeping a challenging level of difficulty for research, testing, verification, thus ensuring that no vacuum is generated by overly ambitious goals. It can also be seen that, in the design of the research tools and knowledge acquisition, there are alternating mechanisms and concrete global approaches appropriate to the ambition of rigorous analysis, allowing students to propose a solution to the problem.

The research objectives can be global and the students are tested via questionnaires (where the specific problem is addressed in a wider environment that can be both concrete and open). In short, the goal is to set challenging tasks in order to maintain a level of difficulty for research, testing, etc., adapted to the pre-established competencies. Tools also alternate between manual and digital format. Web questionnaires and Moodle platform, along with the high level of technical information from technical institutes or manufacturers, stored on the network, allow students to master the in-

Figure 11. Step 4 - 2D works



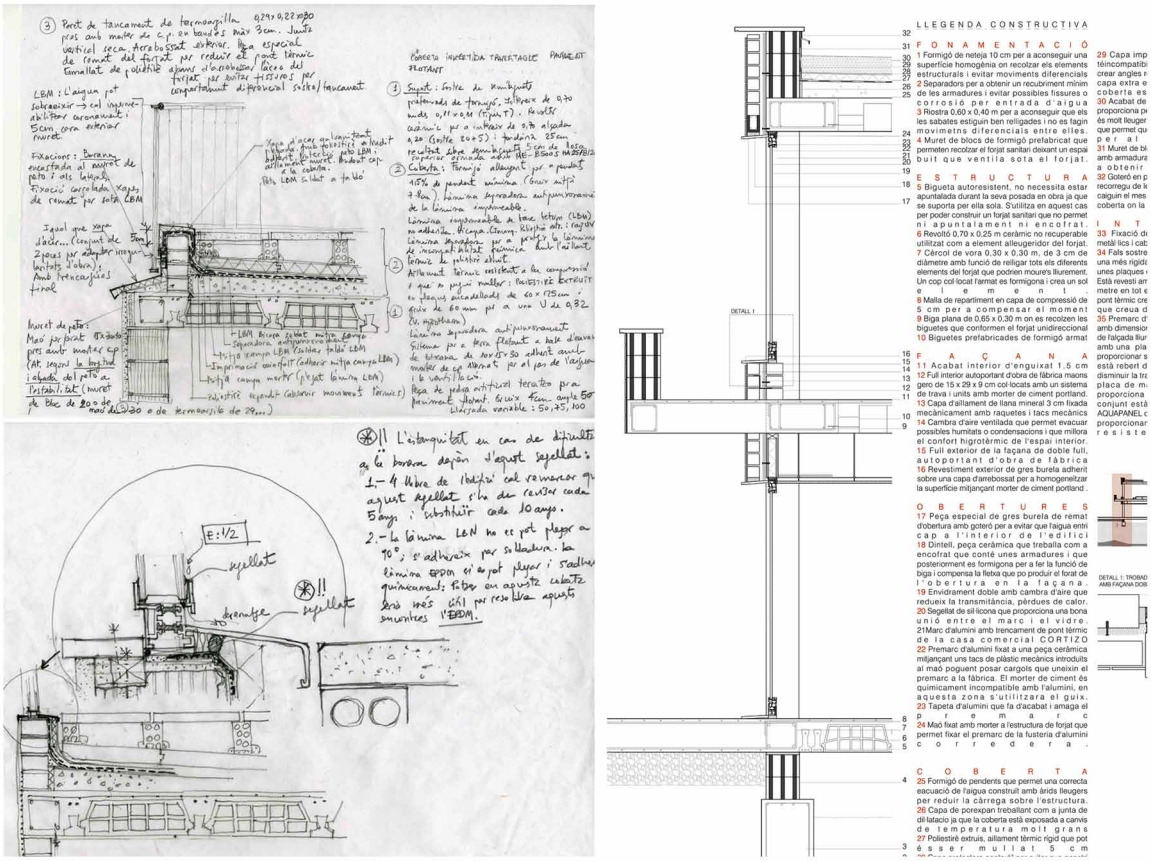
formation and collect data independently based on certain assumptions pertaining to developed PBL blocks. There are a number of tools that allow the students to conduct analysis, synthesis and verification of results outside the classroom, including: Dossiers resources, collaborative workspaces for teams, opportunities for debate teams, groups or entire course

These methods allow students to develop self-monitoring skills and enhance their teamwork performance, thus fostering progress through peer learning. In addition, they help improve social heterogeneous groups (including the capacities to cooperate, to relate well to others and to resolve conflicts). In terms of representation of results and communication, students have several tools at their disposal, which allow them to correct and redo proposals more effectively, show results in 3D, or develop proposals for comprehensive and dynamic communication.

Here, the teacher's role focuses mostly on developing students' critical capacity of reading information and address any doubts regarding information, from source or origin. Maintaining rigorous criteria when assessing information is essential, as this helps distinguish between scientific realities, compliance requirements, and motivations of short-term industry. This prepares the students to face long-term challenges of society, becoming one of the hallmarks of the work with professor, either in person, or through the network.

In this case, the teacher is a cognitive mediator because the student is not given a unique solution and a unique way of thinking. Students take

Figure 12. Step 5 – details



charge of their own learning and self-regulate, in addition to understanding that learning is social and receptive to the ideas of others, to be open to proposals and reconcile conflicting or opposing arguments (Bartley, 2007). The various solutions proposed should address the problem. However, even if the correct solution is not found, the process helps reveal students' weaknesses, which is also highly valuable information, as it helps advance their knowledge.

Representation and communication is understood as an opportunity to reaffirm the concepts learned. Graphical representations, memories and legends are the tools where the result is visualized as a solution to the problem. Moreover, students learn how to reflect and employ the capacity of critical application of theoretical content to specific cases. Therefore, this phase must be completed with great care and, upon its completion; students must be able to communicate what they have learned with highest levels of rigor, from the global system to the specification of particular solutions generic or exceptional.

Strategic Design

Strategic design links different instructions to help students achieve greater awareness of their own learning, consolidating knowledge and allowing them to reference learning tools and skills acquisition. Therefore, compartmental learning should be avoided. Rather, knowledge building should be based on a global vision, be integrative and interactive, linking different subjects

Figure 13. Step 6

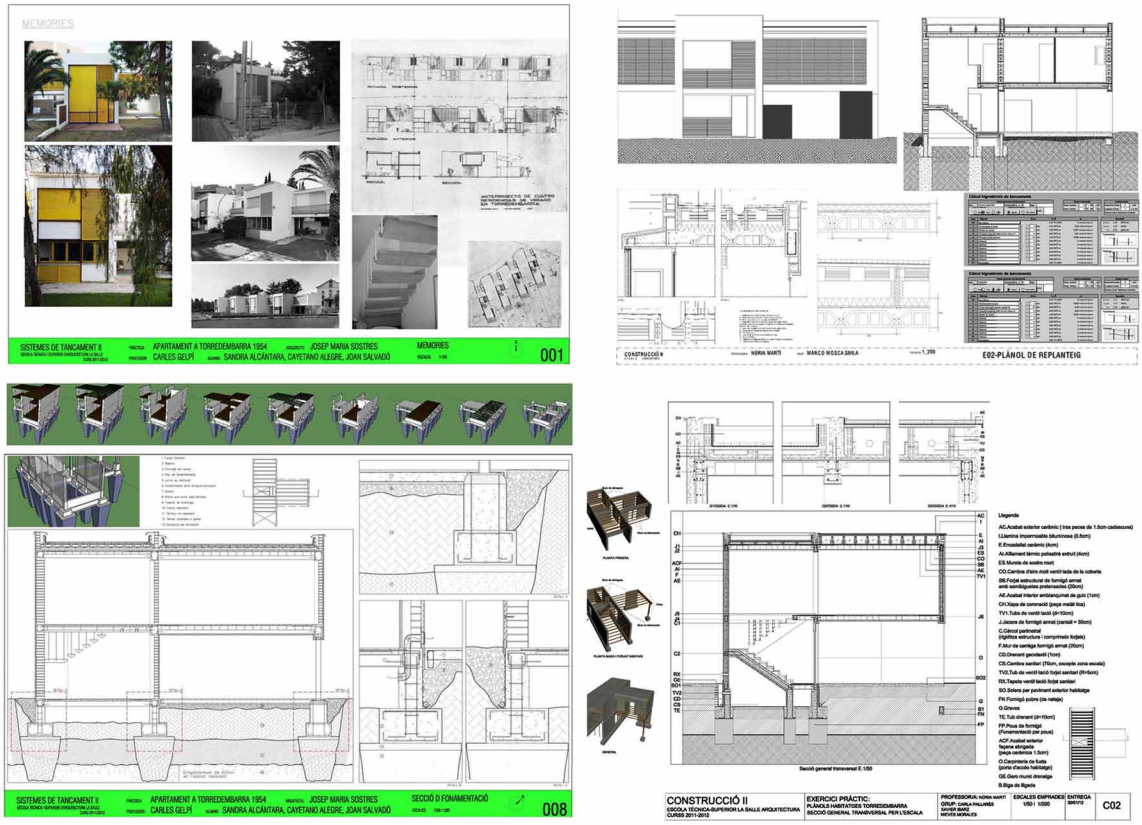


Table 7. Research tools: knowledge representation and communication, along with the steps of P's PBL

Stage	Step	Location	Tools			
			Investigation and Knowledge		Representation and Communication	
			Manual	Digital	Manual	Digital
A	-	Class	Scoring for sketches, proportions / scales, spatial visualisation	U-learning Internet. Web Construction Area (C.A.) www.salleurl.edu/tecnologia	Freehand drawing, sketches	List web references
		Home	IDEM	IDEM + peer communication: networked computer	IDEM	Dossier of information
B	-	Class	Debate.	Information search. U-learning: Web Construction Area.		
		Home	DEM. Search information, bibliography.	IDEM + peer communication: networked computer.		Space Creation Wiki. Chapters.

continued on following page

Table 7. Continued

Stage	Step	Location	Tools			
			Investigation and Knowledge		Representation and Communication	
			Manual	Digital	Manual	Digital
C.1	1	Class	Observation, deduction measures, surfaces, description of materials, contrasting proposals, etc., peer communication: equipment and / or inter teams	Finding information, generic directed. U-learning: Web C. A., articles, and legislation.	Dimensional drawings. Descriptions.	List web references
		Home	IDEM. Search information, bibliography.	Idem. WebQuest. + Communication between equals: Forum WEB-group	IDEM	IDEM. First drawings with dimensions: axis limits, heights. CAD.
	2	Class	Understanding and functioning schemes. A scale. Communication between equals and teamwork	**Finding information, specific open. Cases.** U-learning: information in RED, Web C.A.	Hand Sketch: board / paper	Notes on pictures or computer graphics tablet slate references List web.
		Home	IDEM	Idem + peer communication: Networked computer.	Freehand drawing. Proportionate, dimensioning.	Dossier of information
	3	Class	Checklist requirements. Verification and critical analysis. Debate.	**U-learning:** NETWORK generic information directed Web C.A.	Hand Sketch: board / paper	Notes on tablet or slate computer graphics
		Home	IDEM	Idem+ peer communication: team. Step Work WIKI C2-3		First drawings, complete schedules, lines, CAD measures, up to scale 1 / 200. Lists, descriptions, generic memory.
	4	Class	Division of the problems areas. Work roles. Communication between equals: teams and / or inter teams	Finding information, specific open. Cases. U-learning: NETWORK information and technical company sheets in the construction sector.	Hand Sketch: board / paper	Notes on tablet or slate computer graphics pictures. Dossier information.
		Home	Overall view of the problems worked in class. Communication between equals: team	Idem + peer communication: team. Forum NETWORK group.	IDEM	Modifications drawings, complete schematics, CAD measures. Listings / Descriptions / concrete Legends

continued on following page

Table 7. Continued

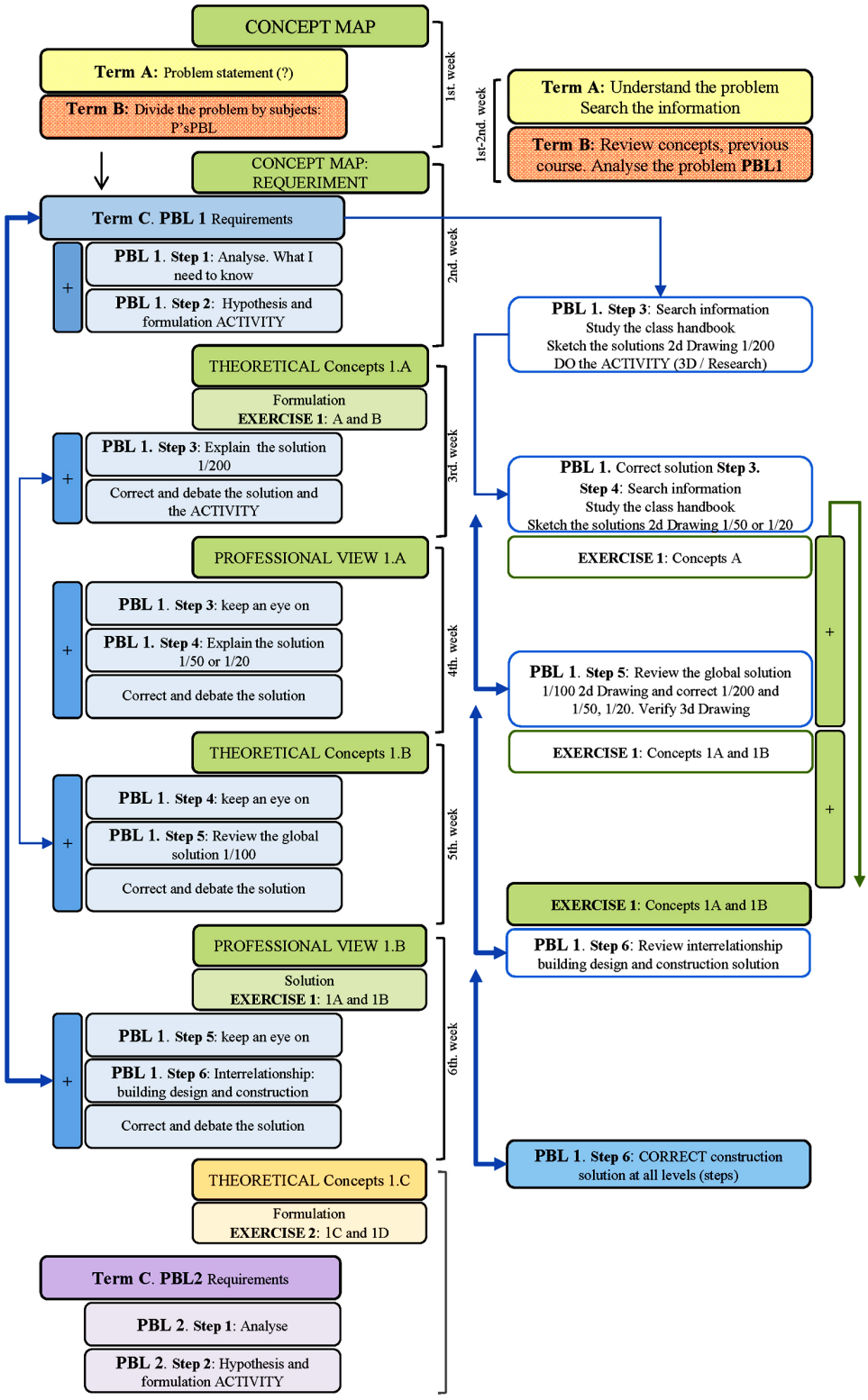
Stage	Step	Location	Tools			
			Investigation and Knowledge		Representation and Communication	
			Manual	Digital	Manual	Digital
	5	Class	Exposure, set in common. Debate.		Freehand sketches provided. Perspective. board / paper	IDEM
		Home		Idem + peer communication: team. Work Step WIKI C3-4	IDEM+ MODEL	Representative construction plans of the hypothesis. Model images. 3D construction
	6	Class	Information requirements checklist step 1	Idem with information pack	Indicative schemes. Memoirs, legends / chalkboard	Checklist completed
		Home	IDEM	**U-learning:** information online Web C. A.	ID + Modifications and adjustments of model, Art and Images	Representative construction plans of the hypothesis. Model images. 3D construction. Images scanned. WIKI PBL. CAP.1
C.x	1_4		IDEM	IDEM	IDEM	IDEM
	5					
	6					WIKI PBL Chap 2 and Chap 1 revision
D			Exposition	PPT, Prezi, Flash player, PDF		Written and graphic record. Different scales. Information Dossier. WIKI.
E			Debate			Checklist evaluation

or disciplines. To achieve these objectives, the unit of theoretical learning and P's PBL follow a strategically planned temporal order.

When addressing the problems in P's PBL, theoretical themes and their relationships have not yet been taught in class. In other words, the student has not received the theoretical knowledge on how to tackle the problem, although he/she can consult notes and other information sources. This implies that, in the first step of Block B, the student must consider "what I know". In this first stage of Step 1, the teacher in the classroom makes a first attempt to address the problem to narrow down and direct the various solutions through leading question-based discussions. This way, the teacher shows different patterns that can be adopted to deal with the problem. From this moment on, the student must continue asking questions approaching the reality behind the problem.

This gap between the two units of learning makes students more independent and self-critical, prompting them to work more actively, while self-regulating their knowledge and being responsible for the acquisition of skills. When this part of the syllabus is applied to P's PBL, it is covered in theoretical classes, and student participation is guaranteed, as the topics covered are already familiar to the students and they can use this time to resolve any remaining doubts. Moreover, these classes reach much deeper into the issues because students can draw upon previous reflections. In this strategic design, seminars take an even more

Figure 14. Strategic design



important role, and involve concrete elements that, by moving to P's PBL, provide tools that can be adopted in analysis, research, representation and communication. All the instructions, combined together, allow students to develop a holistic view of the building as an architectural discipline, which involves many factors and requirements. These are addressed depending on how they are approached in different design solutions.

Practice Designs with the Use of ICT

In the learning process that benefits from TIC, the strategic design of instruction must be clear and properly organized. Having a clear conceptual map is essential to both the student and the teacher.

In particular, each relationship between teaching practices must be considered, which requires:

- **Focus:** The objectives must be metacognitive and immediate. How goals are set and which ICT services should be applied, utilizing both skills and domain-related technologies, such as those supporting some aspects or skills.
- **Method:** What type of instruction should be adopted and how concepts and ICT implementation are introduced. How the ICT should be located in relation to the curriculum.
- **Time:** The amount of time dedicated to practice in relation to the proportion of time set for learning other practices and ICT.

Therefore, if the ICTs are not properly designed in the learning process, they can result in a poor acquisition of knowledge and skills. To incorporate an ICT-based methodology into a specific teaching environment, some recommendations for avoiding student rejection must be considered. Empirical evidence indicates that the focus should be on so-called "good educational practices" that primarily involve virtual rooms, e-learning, and semi-present teaching (Area, San Nicolás & Fariña, 2010; Salinas, 2004). From the specific characteristics that shape these practices, four points can be extrapolated:

- Promotion of professor-student relationships, allowing for a more effective feedback process;
- Dynamic development among students, which is made possible by collaborative techniques;
- Contribution to better task realization by heterogeneous learning methods, meeting high expectations;
- Applying teaching/learning methods based on teaching innovation and new IT technologies.

These new concepts generate a new type of student, who is much more dynamic and capable of having a more participatory role in the educational process (who could be called a '3.0 Student'). In accordance with recommendations of Massy and Zemsky (1995), any methodology that promotes the inclusion of IT in teaching must have the following objectives:

- **Personal Production Help:** Applications that allow both the professors and students to carry out tasks faster and more efficiently (e.g., calculation sheets or text processers, draw programs);
- **Content Improvement:** The use of tools that allow for the notification and modification of content rapidly and efficiently (e.g., e-mail, digital content, video, multimedia resources) without changing the basic teaching method;
- **Paradigm Change:** At this level, the teacher reconfigures the teaching and learning activities to utilize the newly incorporated technologies.

Another point to consider in this new learning model is the evaluation of different directions. This prompts the teachers to question the manner in which various instructional units should be evaluated and what percentages in the final grade should be part of the strategic design. In addition, the student should be familiar of this evaluation system to take responsibility for their involvement. In the evaluation, the scoring criteria have to be clear, and should include the following:

- Response to the reached objectives.
- Evaluation of the work and the adequacy of the proposed solutions in the different instructions; the analysis, the critique and the reflection.
- The difficulty of the instruction and the implications for the students.
- Participation in class and in virtual spaces.

Methodology of the Evaluation

The evaluation methodology may take the form of continuous assessment and / or examinations. For PBL, it is clear that the assessment is continuous, as are all instructions that depend on practice and exercises. However, teamwork requires having different strategies to specifically evaluate any student.

If testing is considered, the type and format of this form of assessment and the instructions pertaining to the discipline must be taken into account. Given that the new model of active constructive learning is based on the content and focuses on skills, memorization tests do not fit into this system. Another consideration would be utilizing the abstraction of the concepts studied and their applicability. Therefore, the type of examination must allow the students to reflect and combine concepts and practical exercises to demonstrate the acquisition of all skills developed both in the classroom and beyond. The format of the examination is relevant, since each type of test is suitable for a specific type of learning. Just as teaching needs different approaches, so do the tests, whereby different types of answers have to be accommodated.

Designing the P's PBL

In the context of P's PBL, close attention must be paid to the following:

- Understanding the problem, the strategies to be followed and their targets.
- Understanding the dimension of the problem.
- Understanding the relationship and the differences implicit in addressing the problem comprehensively and as a bounded system.
- Design steps are responsive to the balance between the hypothesis, thoughtful analysis and work with the material solution that is to be performed. The pace of work has to articulate the discursive part of the proposal embodied.
- Maintaining a quantitative balance of activities, where the focus is on replacing manual labor by usage of digital tools. Manual activity, discussion, verification and manually checking the requirements contributes to the maturity and importance of digital quality of students' work.
- The ability to consider different degrees of maturity of individual students.
- Development of teamwork skills and the ability to react to changes in the group.
- At the risk of simplification, in the absence of the teacher, ability to work on directed activities.
- Oversized work tutor network (the ability to handle both options and extend the distance activity must remain realistic margins tracking.

Regarding P's PBL, both teachers and students must ensure that they:

- Understanding the problem, the strategies to be followed and their targets.
- Understanding the dimension of the problem.
- Understanding the relationship and the differences implicit in addressing the problem comprehensively and as a bounded system.
- Design steps are responsive to the balance between the hypothesis, thoughtful analysis and work with the material solution that is to be performed. The pace of work has to articulate the discursive part of the proposal embodied.
- Maintaining a quantitative balance of activities, where the focus is on replacing manual labor by usage of digital tools. Manual activity, discussion, verification and manually checking the requirements contributes to the maturity and importance of digital quality of students' work.
- The ability to consider different degrees of maturity of individual students.
- Development of teamwork skills and the ability to react to changes in the group.
- At the risk of simplification, in the absence of the teacher, ability to work on directed activities.
- Oversized work tutor network (the ability to handle both options and extend the distance activity must remain realistic margins tracking.

CONCLUSION

Learning by focusing on developing competencies is an intrinsic educational model for architectural education, and it should be able to integrate professional skills, abilities and knowledge and apply them to the design and construction of buildings. This allows the professional to:

- Elaborate architectural designs that satisfy both aesthetic and technical requirements, from a holistic view of all the disciplines of architecture.
- Adapt to new circumstances by drawing upon knowledge (projective constraints of the site, technology types and rules, etc.) and the capacities and skills (requirements of the agents involved in the project, professional structure, etc.)
- Permanently engage in learning, expanding the knowledge of new materials, technology systems, policies and behavior of the constructed buildings, as well as extend the curriculum area and learn new culture, or new ICT tools.
- Act autonomously, cooperating in social heterogeneous groups and use different resources interactively at the level of research and knowledge as tools of representation and communication.

Therefore, meaningful learning of construction based on active instructions is essential for the future architect and the incorporation of ICT in these educational practices is inevitable in the new Information Society. Thus, the incorporation of ICT in learning opens up new psychopedagogical dimensions when considered not only as instrumental but also as an instructional and techno-pedagogical tool. The blurring of boundaries involves working within a framework of information and virtual communication. In architecture, this implies greater use of digital library tools, both graphic and written. Furthermore, optimization of resources and agility in the execution of an architectural executive project allows architects to work with software that links various disciplines. Today, many Spanish governments urge architects to work with programs such as Building Information Modelling (BIM), where the documentary information, i.e., the plans, table costs, and construction details, are developed from a virtual model with the goal of having controlled

all constructive definitions. Therefore, the use of this program implies that the user not only has to master the tool, but also has a holistic view of the entire architectural project. Moreover, these must be approached in all the different scales to obtain the best solution with respect to the requirements set at the beginning of the project.

The incorporation of ICT in educational practice allows architects to:

- Open new architectural conceptual dimensions,
- Intensify work, using computer programs to create documents and virtual environments for communication and information,
- Facilitate the acquisition of generic skills (instrumental, personal and systemic) and specific (knowledge and skills),
- Benefit from meta-thinking and metacognition of their own learning,
- Monitor students' learning.

Thus, the incorporation of ICT in learning opens up new dimensions that are considered psycho educational and can serve not only as instrumental, but also as instructional and techno pedagogical tools.

PBL instruction is a natural approach to the design process, as it follows the pattern of a real architectural project, where all the possible solutions and their suitability to the requirements are established at different levels, always with the ultimate holistic view of architecture. In this sense, P's PBL design approaches complexity of an architectural reality, i.e. the project as a whole. For this reason, separating the project into various problems facilitates its understanding, conceptual assimilation, and critical analysis, thus assisting in finding a valid solution. This way, every solution involves integrating it into the overall approach and observing its effect on the entire project. This represents progress in the solution and allows assessment of its fit within the set, which often involves rethinking the solution. Therefore, this means enhancing the consolidation of knowledge and thoughtful constructive critical analysis.

Through strategic design, the relationship between P's PBL instructions and lectures, along with seminars, the awareness of learning intensifies and helps students gain and deepen their knowledge. Being active participant in their own learning process allows students to collaborate and become more autonomous, while benefitting from the participation of ICT.

The introduction of ICT in the P's PBL brings students closer to their professional careers. Using tools of communication (both verbal and documentary) integrates naturally into the day-to-day learning, as well as information acquisition. The only exception is Ubiquity, which requires discretization and learning criteria inquiries. For students, learning using virtual networks is convenient, as they can do it anytime, anywhere. For digital natives, this is intrinsic; however, their ability to discern the key concepts and create a hierarchy of relevancies is not natural. Therefore, for them, U-learning requires not only understanding, but also knowledge of curricular concepts and ability to filter information critically.

In the present form of P's PBL, information attained by ubiquitous computing is creating demand for more debates and discussions in the classroom, involving active collaboration and teamwork. This study has revealed a mismatch between the evaluation of the accuracy and the adequacy of the information in the context in which students work. However, in order to address this issue, the contextualization of information between the reflective critical analyses of curriculum concepts must be formalized.

The P's PBL with ICT requires ubiquity of information as an instruction that appeals directly to students' interests. It enhances their responsibility for learning and their professional future,

through explanation, inquiry, critical analysis and reformulation of relevant and complex problems. We have shown that the approach to the problem should serve the student to understand that there is a unique solution that can only be found if approached from a complex and complete set of perspectives.

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KEY TERMS AND DEFINITIONS

Cognitive Multifunction: The various cognitive functions that digital natives employ various computer resources when in interactive situations (inform, search, sort,), often overlapping those resources and using them simultaneously.

Conceptual Map: Graphical representation of a set of concepts and their relations in a specific domain of knowledge.

Directed Learning: The model of teaching where the teacher identifies the objectives, teaching content and learning activities to be developed by the student.

Interactive Triangle: The exchange and interactions between three main axes of the educational scenario: the student, the teacher and content.

Meta Cognition: How to learn to reason about reasoning itself, application of thought to the act of thinking, learning to learn, to improve the activities and intellectual tasks you performed using reflection to guide them and ensure good execution.

Meta Reflection: A constant and continuous process of thinking, analyzing, observing and reinterpret the activities and intellectual tasks. Reflection on the meaning of these practices.

Problem-Based Learning: Learning is structured around the explanation, investigation and restatement or solving a problem that appeals directly to student interest.

Strategic Instructional Design: The discipline that deals with the planning, preparation and design resources, methodologies and environments needed to be carried out with specific learning objectives. This design gives a dimension technological-projective instruction that allows a connection between theoretical-explanatory dimension or theoretical-conceptual with the core technical - practical dimension.

Techno-Pedagogical Design: Set of technological tools accompanied by an explicit, comprehensive proposal and precise on how to use them for the implementation and development of teaching and learning activities. The design includes a proposal of content, objectives and teaching activities as guidelines and suggestions on how to address them and develop them.

Ubiquitous Technology: Expression refers to the gradual integration of information technology in different contexts of human development.

Chapter 17
Digital Technologies in Architecture and Engineering: Exploring an Engaged Interaction within Curricula

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ABSTRACT

This chapter focuses on the development and adoption of new Multimedia, Computer Aided Design, and other ICT technologies for both Architecture and Computer Science curricula and highlights the multidisciplinary work that can be accomplished when these two areas work together. The authors describe in detail the addressed educational skills and the related developed research and highlight the contributions towards the improvements of teaching and learning in those areas. This chapter discusses the role of digital technologies, such as Virtual Reality, Augmented Reality, Multimedia, 3D Modelling software systems, Design Processes and its evaluation tools, such as Shape Grammar and Space Syntax, within the Architecture curricula.

INTRODUCTION

New education methods and studio experiences are enabled by the advances in Computer Aided Design (CAD), Visualization and Multimedia technologies. The introduction of digital skills in the architecture graduation curricula is mandatory nowadays, due to the possibility that computing technologies bring to the resolution of several learning tasks (Duarte, 2007, Celani, 2012). Therefore being or not being digital is not anymore an option (Kruger, 2012).

The knowledge about digital processes in design allows students (future architects) to experi-

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ence the advantage these tools bring to the design problem, and to choose to what extend they want to use them. Computers, CAD systems and Information and Communication Technologies (ICT) have changed the architecture teaching schedule through the last four decades, shifting from a role of computers used as simple drafting machines, to the current role of being important pillars of the architecture curricula (Mark, Gross, & Goldschmidt, 2008). Initially ICT/CAD was seen as a separated technological subject in the architecture curricula. Nowadays those technologies have successfully liaised with design subjects, showing the true potential they bring to other curricula topics (Asanowicz, 1998). Recent research, development and commercialization of new products in multimedia, virtual reality, cloud-aware collaborative tools, 3D modelling and computer animation, among others ICT technologies, has played an important role in the introduction of computers in architecture curricula. This is becoming increasingly possible as technology enable better human-computer interaction and its use is getting more natural, obvious and straightforward, allowing designers not to get distracted from their goal which is design (Lawson, 2006).

One of the reasons by which CAD tools, at some point in time, have been rejected in design studio classes, was the controversial relations of designers with computers, due to the fact that designers believed computers could not answer design issues the same way a human designer could (Lawson, 2006). Nowadays computers increasingly perform more and better and may help designers to find and gather knowledge and perform tasks they would not be able to do, without computers and ubiquitous communication infrastructure. One of those tasks made viable by ICT, is the possibility of evaluating the quality of architectural spaces, prior to the construction phase, through the simulation of the designed space in virtual environments (immersive or semi-immersive), which has earned interest in the academia, from both the scientific and teaching perspectives. At the same time, digital tools have been used to predict peoples' behavior within built environments, to identify design problems and also its potentials (Hillier & Hanson, 1984; Hillier, 1984; Penn et al, 1997; Drettakis, Roussou, Reche, & Tsingos, 2007).

In this chapter we present the strategies for using Digital technologies in Architecture and Computer Sciences curricula in our school at ISCTE-IUL, regarding both the available facilities and equipment, the pedagogical methods used and results achieved so far. We end with some discussion on the advantages of adopting such technologies for teaching Architecture and its related studies.

DIGITAL STRATEGIES FOR ARCHITECTURE AND COMPUTER SCIENCE EDUCATION

Digital technologies are used in multidisciplinary methods for education and research in both Architecture and Computer Science. In the Integrated Master of Architecture (IMA) of our School (with five years graduation), the approach towards architecture education lies on the convergence of various scientific areas around the project activity, which promotes a practical and theoretical reflection in order to provide the student with informed, critical and autonomous thinking, regarding the various dimensions of space. Architecture is seen as a transversal practice within the scope of several knowledge areas. The IMA programme explores architectural design methodologies through the understanding of space and all the variables that affects it in terms of function, structure and plastic expression. Building technologies, representation and communication techniques are articulated with the design methodology, from the very beginning of graduation. On the other hand, since IMA is integrated in the School of Technologies and Architecture, it promotes a deep link with the areas of Information and Communication technologies,

Computing and Multimedia that manifest themselves, besides education, also in research activities and in advanced lab infrastructures, available for several curricula practices.

The approach adopted in our School involves the introduction of multidisciplinary work in order to familiarize students with social communication, collaborative working and team working soft skills. Taking advantage of being part of the School of Technology and Architecture, our methodology introduces architecture students to Digital technologies, from a user perspective, since the very first year of graduation and, by suggesting its use in several courses with different goals, allows them to judge their effectiveness. In these first years, Digital technologies are presented in specific courses to extended groups of students. Later in the curricula, students are invited to explore digital skills in smaller research groups, in the scope of their Master thesis and integrate teams with Computer Science students, as well as Psychology, Ergonomics, Human-Computer Interaction, Serious Games, Computer Graphics, Computer Vision, Virtual Reality, Augmented Reality and Software Engineering researchers, geared at developing multidisciplinary research and foresting innovation. In this rich research environment, students define their own design questions and in such multidisciplinary teams, new digital tools are created in the context of MSc and Ph.D. Thesis projects, enabling automation of prior manual and error-prone processes, introducing (for conceptualization, development, test, evaluation and design life-cycle enhancement), new paradigms and tools for Architecture design. Examples of such projects are, natural interaction (via speech) with life-size digital-mockups of buildings, described by BIM – Building Information Model, in immersive Virtual Environments, Augmented Reality interaction and visualization applied to Architecture scale models, or mobile digital tools.

FACILITIES AND EQUIPMENT

The Architecture programmes at ISCTE-IUL uses several learning and research facilities that range from the traditional design studio room, to dedicated full equipped labs. We have specially gained interest with Virtual Reality – VR settings. One of the main advantages of VR is flexibility. The use of VR allows the systematic manipulation of the environment's layout, and different kinds of Architectural settings can be designed to create suitable experimental conditions for studying controlled variables. VR also allows monitoring and recording the behaviours through which an explorer gains spatial knowledge for further evaluation (Morganti, Carassa, & Geminiani, 2007). The studies of Vilar and colleagues (2013a, 2013b), Cubukcu and Nasar (2005a, 2005b), Moffat and colleagues (2001), Omer and Goldblatt (2007), and Umemura, Watanabe and Matsuoka (2005) are some examples of research using VR-based methodologies, targeted at the studies of human behaviour regarding the architecture variables.

The CAVE-Hollowspace (Costa, Pereira, & Dias, 2007; Soares et al., 2010) at Lousal in south of Portugal, is used by our team to develop dedicated research and two other Pocket CAVE VR facilities, are available in our school to support research in masters and doctorate programmes of the Architecture and Computer Science departments. The CAVE™ - Cave Automatic Virtual Environment (Cruz-Neira, Sandin, DeFanti, Kenyon, & Hart, 1992) - is a full-immersive virtual reality (VR) system that generates and projects stereoscopic images at interactive speeds (~60 HZ) on the walls and floor of a room-sized cube to provide the illusion of presence and immersion. The Lousal CAVE comprises four projection planes in a parallelipipedic U-topology with six pairs of stereoscopic (3D) high-resolution projectors. With this infrastructure, researchers are able to use immersive virtual reality environment with stereoscopic visualization to simulate real-scale virtual environments and create rich

user experiences from the visual and aural point of views (Cruz-Neira et al., 1992). Additionally, the CAVE may also include haptic interfaces that recreate the sense of touch by applying forces, vibrations, or motions to the hands of the user, room temperature variation, wind, or smell, when provided with specific hardware and software.

The Pocket CAVE labs are part of the Information Science, Technology and Architecture Research Center (ISTAR-IUL, available at http://istar.iscte-iul.pt) that is located at our school. Both run the same in-house developed VR software of the CAVE at Lousal and therefore, we are developing projects that are also available for this facility. A Pocket CAVE, is a portable, single-screen, semi-immersive virtual reality system (Gutierrez, Vexo, & Thalmann, 2008) with a large-scale projection wall (4 meters x 3 meters), in which stereoscopic images are rendered through a 3D high-resolution projector (which supports HD 1280×720p in stereoscopy). Images are visualized using shutter glasses. As mentioned, we currently hold two such Pocket CAVE VR labs. Input interaction is enabled via natural means (speech), full body gesture (sensed by the latest Kinect for Windows sensor), or more traditional devices such as a Joystick. One of the labs (*VR Lab*) includes user pose tracking via infrared sensing (Optitrack). The same lab supports Ambisonics sound system, providing true 3D synthetic sound experience in order to consider the effect of sound renderings in the user's behavior interacting with architectural spaces. The other lab (*PocketCAVE Lab*), provides a 7:1 surround system and Binaural Headphones/microphones. In our VR labs, users who participate in several experiments are monitored through non-invasive biometric sensors (Electrodermal activity, Electrocardiography and Electroencephalography), mainly used for studies that sense, process and statistically analyze some features of the physiological signals generated by the users themselves, while walking through pre-defined locations in Virtual Environment. We are especially interested in detecting events of arousal responses, from where we can derive emotional responses, such as the fear of falling during space use, to better understand the perception of architecture spaces by their inhabitants.

In each lab, there are also available for research purposes, stereoscopic head mounted displays (HMD – Oculus Rift 2.0) and a binocular eye-tracker system (Dikabilis Ergoneers) compatible with our VR technologies. The HMD is very useful when researchers need to develop more immersive context that are important to improve the sense of presence, promoting a reliable behavioral response. However, as it has higher occurrences of simulator sickness than the stereoscopic projected images, the VR setup with the HMD is mainly considered when interaction time is reduced. The binocular eye-tracking system allows researchers to go further on human-environment behavioral analysis and investigation. With this eye-tracking system, researchers are able to collect information about visual attention, visual exploration patterns, gaze fixations, time spent on gaze fixation, saccades, among others that have high impact on the analysis of space use.

The CAVE-Hollowspace in Lousal Science Museum and the Pocket CAVE infrastructures, were both developed by ADETTI-IUL (Advanced IS/IT Research Center, ISCTE-IUL) team in collaboration with several universities and institutes, with impact in the exploitation of virtual reality systems.

CaveH Spawner (or CaveH, for short) is the in-house software that enables real time rendering and interaction in the virtual environment. It was developed at ADETTI-IUL and Microsoft Portugal, as a standard software system with full support and troubleshooting by our team, enabling the development of new features each time a new request originates from Architecture, Psychology, Computer Graphics and/or other research teams (Soares et al., 2010). An in-house developed software for Augmented Reality - AR experiments (described later) is also available at ISTAR-IUL, referred to as ARch. This system is the result of

the extensive experience of more than 12 years of the team in Computer Graphics, Computer Vision and Augmented Reality, and was recently developed in the scope of three master thesis (two in Architecture and one in Computer Science), which targeted several aspects and requirements of architecture design, within an AR setting, using mobile devices. As a result, we have developed a software tool in which users are able to interact with a 3D virtual model in Augmented Reality, in order to visualize and interact with different projection plans, hide/unhide layers (different buildings specialties, such as architecture, structural engineering, water and sewage, etc), among other features, much like the interaction with a physical scale model.

Carvalho and colleagues (2013), in the scope of augmented reality applications, proposed an integrated analysis of object descriptors and appearance models through their comparison in a common object tracking solution, contributing to understand the object description methods and their impact on the tracking process.

In addition to these facilities, normal computer labs for software classes and extracurricular use by students and researchers, are also available. Studio classes and other theoretical courses are taught in large rooms. Studios offer large tables enabling collective work, where students can use their laptops (those are not considered to be the essential tools, but instead part of the workflow).

Multidisciplinary Education and Research

Architecture education is based in a convergence of various scientific areas, promoting a holistic and interdisciplinary practical and theoretical reflection in order to provide students with informed, critical and autonomous thinking regarding the various dimensions of space.

Our University Institute allows for a unique set of synergies in Portuguese's Architectural education and research which considers also the contribution of other areas like Sociology, Economy, Computing, Anthropology, Business management and Public Policies. Architecture is integrated in the School of Technologies and Architecture which promotes a deep link to the areas of Computer Science that manifest itself in the areas of research and in the available infrastructures. We encourage students to take elective courses on other areas of knowledge ranging from Computer Science, Psychology, Sociology, Anthropology, Entrepreneurship or Economics, to pursue cross-disciplinary approaches on problem solving. This approach also attempts to bring students closer to what happens in industry and companies where expertise work in a multidisciplinary environment (Brindley, Doidge, & Willmott, 2005). It's known that work developed at courses attended both by students from Architecture and other areas like Computing or Multimedia, has the potential to be of higher quality (Entwhistle, Thompson, & Tait, 1992; Higgins, Maitland, Perkings, Richardson, & Warren-Piper, 1989). This is visible, e.g. in courses where technology meets the arts, or art related topics. For instance, in the Sound and Video for Multimedia (SVM) course, projects tended in the past to be less creative and "content dry", lacking the development of interesting ideas and focusing mainly in tech details. Since students from degrees, other than Computer Science degree where SVM is mandatory, started to enroll at SVM as an optional course, results have been very interesting since ideas are brought from outside the Computer Science "box", with mixed students' backgrounds producing overall much better projects. With the same goal of promoting interdisciplinary approaches, last year our School of Technologies and Architecture started to promote an annual competition on design with the target of developing innovative designs, combining architecture with ICT. Teams had to be multidisciplinary and the proposed design (a small shelter to place e.g. in an university or airport) had to be

feasible and innovative. This competition was a central starting point to promote multidisciplinary approaches to design.

Our research team gathers 3D Computer Graphics, Serious Games, Computer Vision, Virtual Reality, Augmented Reality, Human-Computer Interaction, Architecture, Ergonomics and Psychology researchers. This collaboration promotes the development of a more holistic approach towards research, enabling our team not to focus only on a specific area of knowledge, but to have a broader overlook on the research problems, by applying a system thinking process.

In this multidisciplinary approach, we focus architecture education in architectural themes, keeping the goal to obtain broader competences in this area. Students are nowadays aware that the traditional way of working in architecture, although holistic, may not give them the skills to work in all the areas that we can now identify as prevalent in today's practice of Architecture. Therefore the number of students that attend elective courses of Programming, Computer Graphics, Entrepreneurship, Management and also Psychology, Sociology, Anthropology and other social sciences, is increasing. In our research activities, we try to balance the goals of each different scientific area so that there is not a predominant area. Usually architecture is the problem deliverer since our research is focused on the study of constructed spaces, both about the design process and the impact buildings have in users. In the early stages of this research process, the Architecture team usually takes the lead by defining the scenarios and personas that enable this group and other teams to understand and capture research problems. Then we derive research hypothesis and requirements that eventually drive Computer Science, Psychology and all other teams' research activities. In the end, the outcomes of our multidisciplinary research are very relevant to all the scientific areas involved, as all are able to draw relevant conclusions that are publishable in the best journals and conferences of each area. Recently, Mathematicians and Statistics researchers have also joined the team, contributing in more complex problem solving research. This collaboration within different areas of knowledge has proven to be extremely rewarding but at the same time very demanding, since it implies redefining research questions and methods outside the normal processes each area has established as "standard", as well as it considers new "out-of-the-box" understandings and views of phenomenon and research questions.

Work developed to analyses user's emotions while walking in simulated spaces (described later in this chapter) involves researchers and students from Psychology, Architecture, Ergonomics, Serious Games and Computer Science (Computer Graphics, Virtual Reality, Software Engineering), as well as Mathematicians, that contribute with tools for analyzing large sets of complex experimental data.

METHODS AND RESULTS IN ARCHITECTURE AND COMPUTER SCIENCE EDUCATION

The combined use of different Digital technologies for visualization, simulation, generation, and evaluation, allows designers to test several design solutions after getting more informed about their capabilities and weaknesses. For example, the CAD paradigm has changed from a passive tool to a powerful and active process of searching for design solutions and alternatives based on specific contexts and variables. Although CAD tools have nowadays a relevant role in architecture education and practice, the architecture design we envision does use these tools, but as part of the design process. Students are encouraged to employ manual techniques during conceptual design phase that usually requires designers to sketch while exploring and communicating their

ideas to themselves and to others. Sketches and physical building models are part of the daily work of design in our university (Figure 1 and Figure 2). These manual technics, as Ibrahim & Rahimian (2010) states, have nevertheless limitations with the increase of complexity of the design problems. For Lawson (2006), we can no longer immerse students in a few traditional crafts but instead, we should encourage them to exploit new technologies as they develop. Following this line of thought, we are providing the means for technology to be developed with the students themselves and according to what we have identified as new emergent problems in architecture. Digital tools are progressively introduced in courses so that the ability to think and design with a critical view, is still a skill not absolutely dependent on computer tools. With this approach, architecture students are able to develop new competences in a critical manner, considering not only architecture by itself, but also the many other valences involved in architecture design.

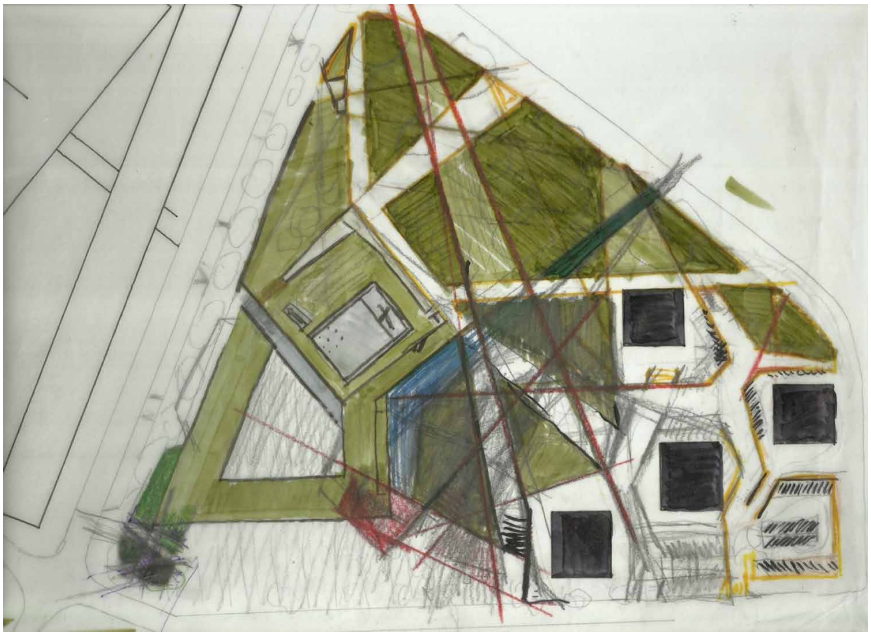
We address education and research in Architecture in four main areas, that are defined in more detail the subsequent sections, namely: Process, Data Collection, Evaluation and Representation. In the Process section, we focus on the entire design process and on how digital tools may provide aid. The Data Collection section, addresses methods to obtain data about buildings and how their inhabitants live in. The Evaluation section focuses on the digital tools used specifically to evaluate existing and proposed designs. Finally, the Representation section addresses digital tools used to represent architecture design.

Process

The development of efficient design methods is an important aim in Architecture. Advanced representation procedures and visualization systems may be combined with generative design tools and collaborative design processes, in order to enable efficient designs to be created.

Figure 1. Physical scale models used in the conceptual design phase.
Luís Coroado.

Figure 2. Sketches of the conceptual design phase
Luís Coroado.



The use of 3D modelling tools, VR systems and other Digital technologies like Augmented Reality for the early stages of the design processes, allow students to get to know better these technologies and make them part of their design processes from the start of their education as architects. Later, when students have already knowledge about construction processes, Building Information Modelling (BIM) is introduced and the approach through the constructive thinking is related to the overall design process. These technologies are used in a second stage of learning, when the skills to define building construction are already required to students.

Virtual Reality

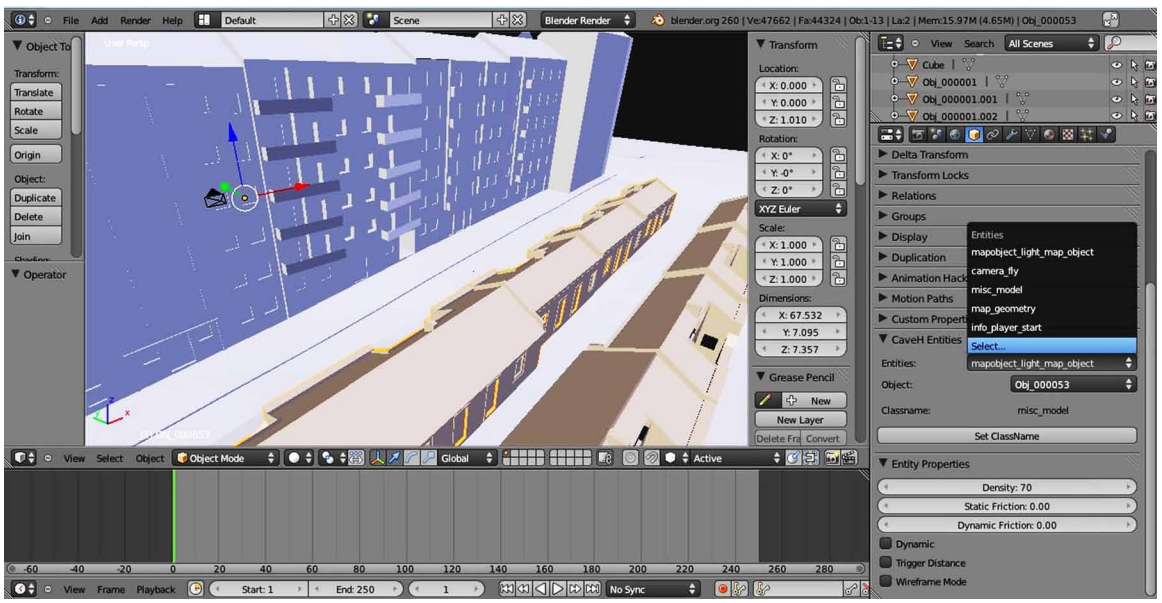
Interactive visualization systems like Virtual Reality (VR), enable real-time and real-scale perception of space and constitute relevant tools for architecture education in design studios and for collaborative tasks (e.g. Schnabel, Kyan, Kruijff, & Donath, 2001; Schnabel, & Kyan, 2003; Petric, Ucelli, & Conti, 2003; Horne 2008). According to Freitas and Ruschel (2013) VR would have a large impact in the learning process if it was applied in the early years of undergraduate courses, changing the status of students from observers to real participants in the learning process.

Our semi-immersive PocketCAVE facilities and in-house developed VR software (CaveH), are being used today by architecture students to visualize their design projects. These students have been defining new system requirements that emerged as needs from their own design projects. Architecture and computer sciences' students and researchers are continuously working on new features for the RV system to accommodate those requirements, so that all students, independently of their knowledge about technology, will eventually use the RV system to test their designs. Nowadays the system allows 3D models to be imported from various commercially available tools, widely disseminated in both academia and industry, such as Autocad, Rhinoceros3D, 3D Studio Max and Revit (Coroado, 2014). The data exchange pipeline, from

3D modelling (using the mentioned tools) to VR interaction and visualization in the PocketCAVE, follows a given recipe. Before being imported to CaveH system, all original 3D models have to be imported by Blender, where the 3D scene is composed. Each 3D scene requires the definition of a set of scene entities: light sources are added, material proprieties of the 3D scene objects are edited, animations are associated with scene objects and optionally, with the virtual camera, animated virtual characters are defined, Newton mechanics proprieties are set to all objects and other scene elements that constraint the user experience in VR are added, such as time-based and proximity triggers and actions, The resulting 3D scene with all the configuration, is exported by Blender in the native format that the CaveH VR system can parse and interpret, OpenSceneGraph or .osg (Figure 3).

BIM modelling is increasing considerably within the architecture community, and the advantages of their use are now obvious to students. The use of Revit generated BIM models in our VR system, has been tested recently, using a similar data exchange pipeline with a special developed VR Visualization tool, referred to as VIARmodes. This tool allows switching between different visualization modes when navigating in VR, namely: opaque volumes, "x-ray" (translucent) volumes and textured volumes. These possibilities enrich the visualization and exploration of space by allowing the designer to acknowledge her/his designs in a greater detail. VIARmodes was created based on requirements extracted from a survey done to a large sample of architects, about the tools they use for a given design process stage (prior to construction activities) of the Portuguese practice, namely, Conceptual Base Programme, Previous Study, Base Project or Execution Project (Coroado, 2014). VIARmodes was designed to aid the design process specially in the stages where different specialities need to collaborate towards a final and coherent design, notably, during the Base Project stage. In VIARmodes, the 3D scene should be modelled so that it has several layers, where each one is associated with a given speciality or sub-speciality. VIARmodes allows the users to select all layers or a subset of

Figure 3. 3D model of a building created in Blender and being exported to the CaveH VR system.
Source: Moural, Eloy, Dias, & Pedro, 2013.



them for visualization and discussion amongst different design specialists (Architect, Structural Engineer, Electricity Engineer, etc.). In the 3D scene presented in Figure 4, six different layers were selected when activated the Layers Mode: Structure (red), Walls (yellow), Pavements and Ceilings (Orange), Openings (Blue), Infrastructures (green), Equipment and Furniture (grey).

Besides the architecture use, this VR system is deeply explored by students from Computer Science as a tool to develop new Computer Graphics features.

Building Information Modelling

Although both the construction industry and designers are still adopting BIM at a slow pace, soon this technology will become the standard for design projects and all the players will have to adopt it. Providing students the knowledge and skills about the logic of BIM models is therefore mandatory.

BIM is part of the architectural curricula from the 3rd year of graduation and is treated both as a software tool and as a design process. BIM is introduced in a dedicated course as a tool to design and enable the representation and quantification of the architectural design and as a tool that enhances building construction knowledge and incentivises students to comprehend design in a broader way. Since the moment students start to use BIM, new aspects of design comes alive: incorporating knowledge, technology and collaboration within architecture and especially with other expertise and other stakeholders. The way BIM's models incorporate information that can later be used for several stages of design and construction, turns it a powerful tool for everyone related to the construction industry. The benefits that this technology brings of decreasing the risk of information loss as well as the possibility of evaluating building design and increasing its performance, are already recognised in the literature by several authors (e.g. Achten, 2009; Sanguinetti, 2009).

Thermal and acoustic evaluation as well as geometry and regulatory requirements evaluations, are subjects that are addressed in other courses of the architectural programme and may use BIM technology to make them clear and effective to students. As far as this relation between geometry, information and building performance evaluations are clear to students, BIM starts to be used instead of traditional CAD systems.

As mentioned before, BIM is nowadays one of the most used CAD software and the goal is to integrate it with the other digital technologies we are working with, such as VR. Collaborating with industrial stakeholders, construction companies and other public institutions that have a decisive role in licencing projects, is a priority than can benefit our research and educational curricula.

Figure 4. From left to right opaque volumes and x-ray volumes with and without some construction elements. The model, Villa Savoye, was modelled using BIM data formats.
Source: Coroado et al., 2014.

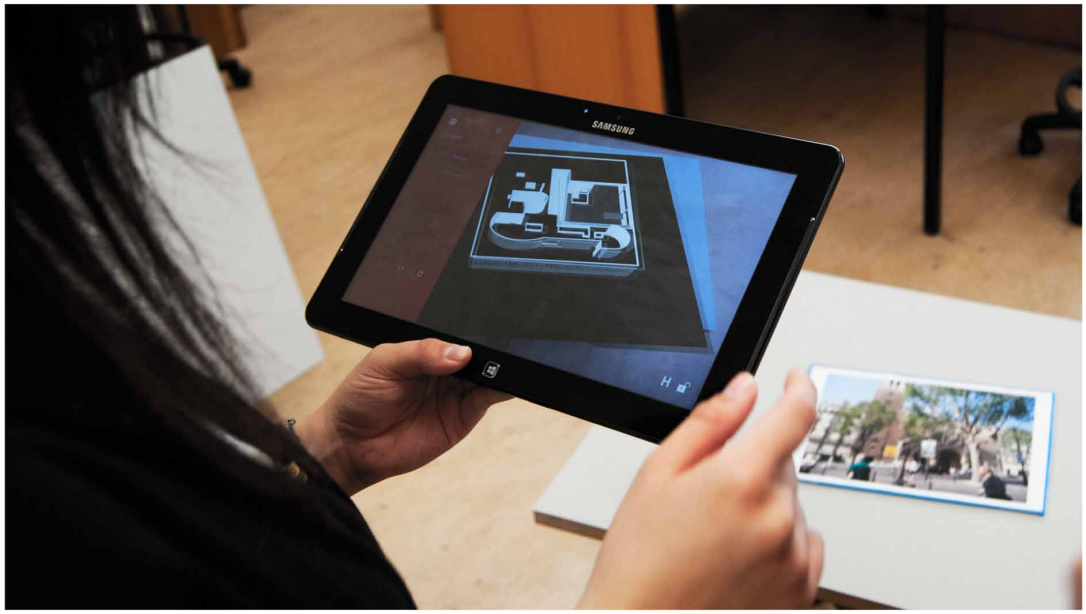
Augmented Reality

Three-dimensional physical models play a fundamental role in Architecture design work, not only as a useful instrument for communication across teams during all the design process stages, but also as media to communicate architecture ideas in exhibitions, meetings and client briefings. Besides the traditional building models that students still produce and are essential in early processes of conceptualization (Figure 5), representing and visualizing architecture designs by means of Augmented Reality - AR, can complement those traditional techniques and therefore is an area we are developing. In this context, we have specified and developed an interactive AR app for Windows tablet devices, referred to as ARch, to be used during the design process. The ARch app allows the 3D models to be visualized with AR on a tablet, using texture tracking based on computer vision, which requires a planar visual marker (a regular colour or greyscale image) that works as a plane for the registration of the model (Figure 6). The app was developed to be use in a tablet running Windows 8.1, with an in-house developed AR system called NUTTS (Natural Ubiquitous Texture Tracking System) (Bastos, 2008) and with 3D Computer Graphics technology based in OpenSceneGraph (Wang, 2010). Much like for CaveH and VIARModes, the used programming language was C++, common to all our systems (Lopes, 2014a). ARch composes four main modules:

1. **Video Input:** Responsible for the video image acquisition;
2. **Visualization:** To where the image with Augmented Reality effect is passed through;
3. **Tracking:** That creates and tracks in each video frame, a virtual camera pose (position and orientation relative to the reference frame of the textured visual marker), that mimics

Figure 5. Example of a building represented by means of a physical scale model.
Luis Coroado.

Figure 6. Tablet interface and touch interaction within Arch, an augmented reality app.
Source: Lopes et al. 2014.



the characteristics of the real camera and sends this camera information, in each frame, to the "Visualization" module, guarantying the perfect registration (alignment) between real and virtual worlds;

4. **Interaction:** Module receives the users' commands and execute the requested actions on the virtual world as well as show the active functionality at each moment.

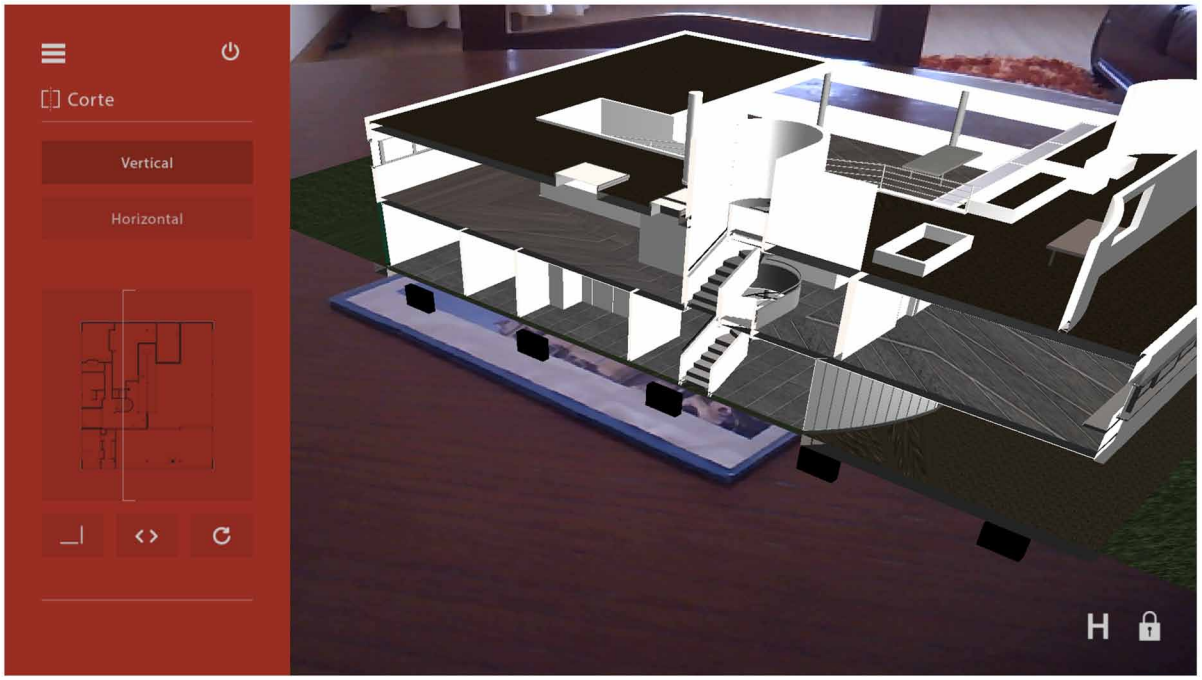
The system allows a number of features that makes easier the user experience (UX) and support its use during the design process. The available features are:

1. Visualization and interaction with the virtual 3D model by using touch in the tablet surface;
2. Execution of vertical and horizontal cutting planes (sections and floor plans), that allow a visualization of the entire design's geometry (Figure 7);
3. Highlight of a group of objects gathered by layers corresponding to design specialties (Structural Engineering, Electric Engineering, Telecommunications, among others);
4. Occlusion and selection of some construction element or group of elements and;
5. Change of the colour or texture of a preselected object (Lopes, 2014b). To enrich the viewing and interaction experience with the 3D model (Figure 6).

Generative Design Tools

The introduction of computing techniques in the conceptual process of architectural design has a large impact in the process of form generation. Generative processes based on shape grammars introduce new methods of composition and design where the design principles, instead of the final result, are the main goal.

Figure 7. Performing a section in augmented reality with ARch app.
Source: Lopes et al. 2014.



Shape rules explain the principles that regulate a design. Examining the use of those principles and the final results, allows us to manipulate them in accordance to the evaluation one does to the final results. Shape Grammars (SG) are particularly suggestive and appealing to architecture because they address the relations between shape elements as proportion, symmetry and emergence. They constitute therefore a good intellectual learning method allowing an abstract and systematized approach on architecture.

According to Knight (1999), shape grammars should be addressed in design education by the means of simple formalisms, avoiding complex labels and parameters, which are useless for the first designs approaches. The use of this design method should start without computer implementations but instead, a manual computation scheme should be addressed which enable a better understanding of shape grammars logic. Although computers are powerful tools to use and explore SGs, there are still no friendly interfaces available, to work with them and fully exploit its possibilities. In the context of using shape grammars for the generation of architectural design, our team is working on the development of a computer grammar interpreter and its graphical user interface (Reis, 2013).

We consider that the second stage of architecture education, is the appropriate period to introduce these technologies related to generative design methods, which enable the students to develop their ability to define design strategies and principles that guide the design process into the definition of several solutions. SG's methods are used with students both in dedicated courses, which introduce shape grammars or, occasionally, in architecture studio courses to enable the exploration of design strategies.

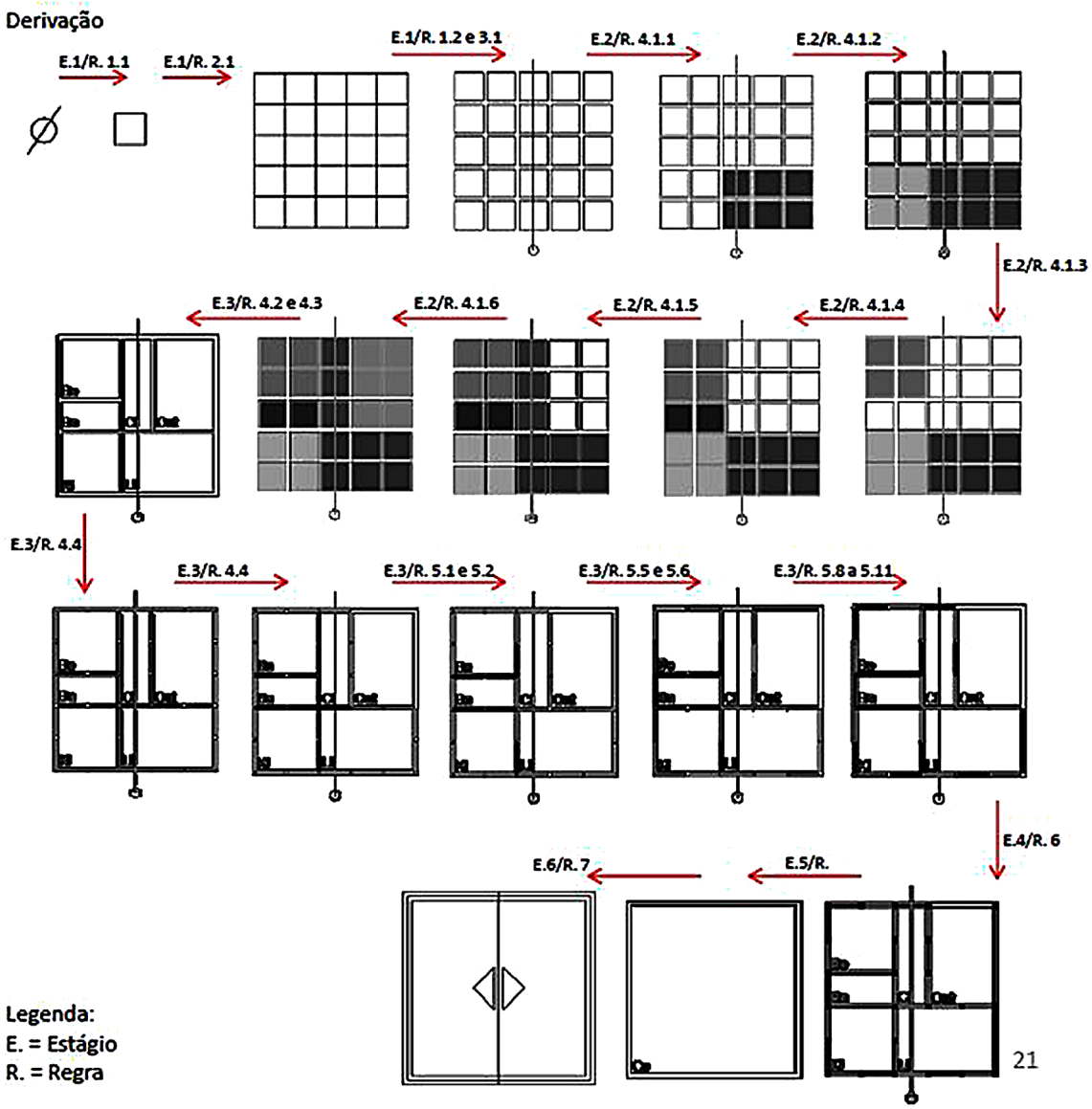
Shape grammars are used to create both two-dimensional and three-dimensional spatial compositions, and their non-deterministic characteristic enables students to explore several design possibilities. To take advantage of the SG potentialities students should have well developed

design skills and a good spatial understanding of objects. In extended groups, SGs were introduced in under-graduate curriculum, so that they can be used later, as a design process, in individual designs and master thesis, when students are already comfortable with architecture design methods and are able to explore with confidence alternative methodologies.

To develop the mentioned skills, SG is introduced through a series of practical exercises that enable the generation of designs and the understanding of the role of spatial relations between architectural elements (Figure 8).

The development of analytical grammars is another strategy used in SGs courses, in order for students to understand certain styles and lan-

Figure 8. Shape grammar developed for a modular wood frame construction system
Raquel Sousa and António Santos, 2011/2012. Course Shape Grammar and Digital Tools, teachers Alexandra Paio, Sara Eloy, Joaquim Reis.



guages of design (Figure 9). According to Knight (1981), understanding past architecture through the development of a SG, is the best way to get to know different design principles and allow students to focus on the simplicity of complex buildings or systems and get the essence of them. On the other hand, original SGs enables students to define principles of composition that respond to specific design problems and allow them to find several solutions which can then be compared and evaluated. This design method is used by students to define preliminary design solutions so that they explore a large diversity of semantically and syntactical correctly designs (Ferrão, 2013).

In design studio, some students use SG as a tool in their early design stages. With few shape rules, they can test and simulate a large variety of solutions that fulfil their design criteria and the predefined constrains (Figure 10, Figure 11). The task of designing a grammar imposes on the architect the need to be more consistent to the principles that structure his/her thoughts and design ideas and therefore the grammar should support in a precise way the design decisions. The interest SG brings to architecture design comes from the understanding that rules intervene not only with shape but also with design requirements. This means that when applying a shape grammar to an architecture design, functional predicates have to be introduced into the language of the grammar, otherwise an architectural problem may be considered as if it is a "shape game" (Mitchell, 2008, p.197).

The integration of SGs in architectural curricula is also done by promoting external workshops, where students are invited to work together with

Figure 9. Shape grammar developed for detached single family housing
José Luís Silva and Miguel Nóbrega, 2011/2012. Course Shape Grammar and Digital Tools, teachers Alexandra Paio, Sara Eloy, Joaquim Reis.

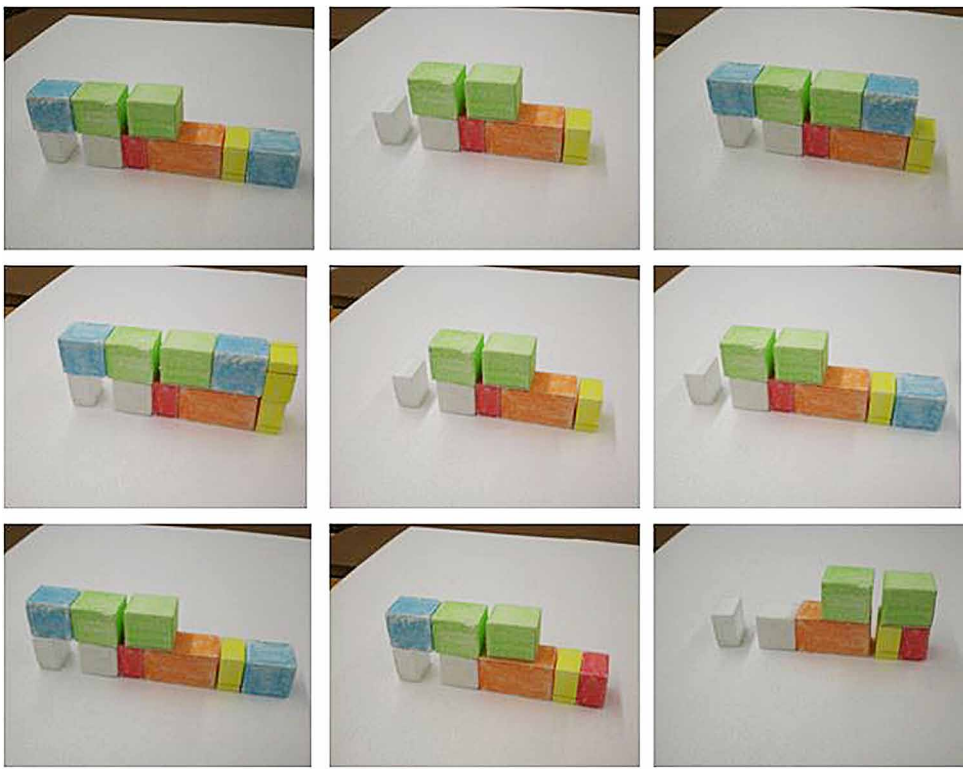
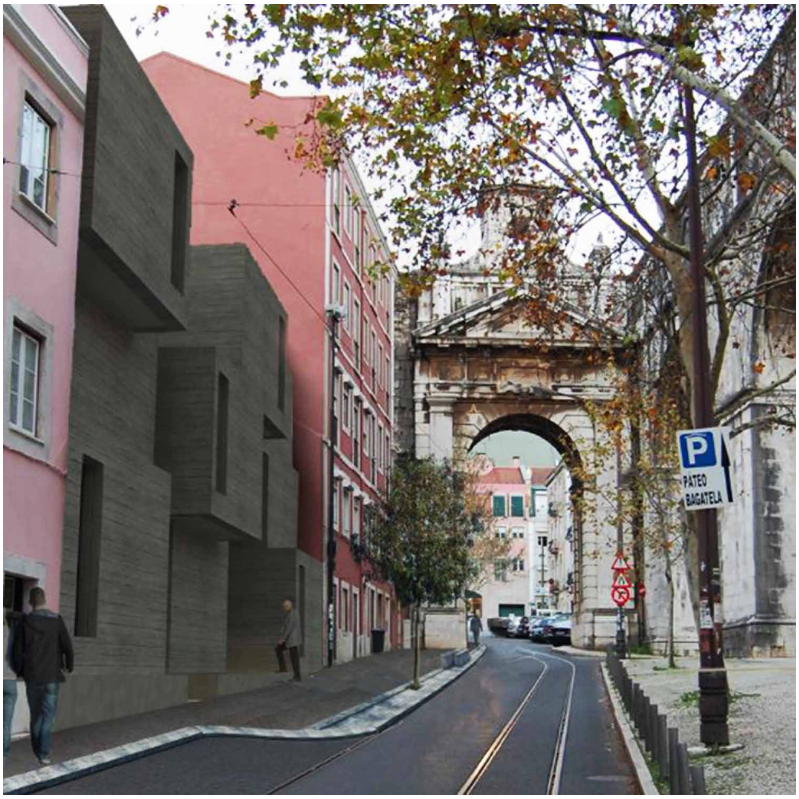


Figure 10. Design solution achieved by the use of shape grammar
Source: Ferrão, 2013.



other participants from different backgrounds and countries. The workshop "Re-inventing ceramic tiles Using shape grammars as generative method for pattern design", was held in Porto, north of Portugal, and joined participants from Netherland, Australia, Turkey and Portugal. The workshop aimed at looking at traditional ceramic tiles design techniques, as a starting point to re-invent patterns and textures using SG and its application in spatial compositions and considering the use of different design, materiality and three-dimensional solutions. Patterns where use to infer shape rules and then transform them to define new design languages (Figure 12 and Figure 13). Our approach enabled to investigate how different people can infer different rules from the same pattern to create a language of design (Benrós, Eloy, & Duarte, 2014).

Development of Auxiliary Tools

As a starting point for the development of a SG to the definition of customized housing layouts (Eloy, 2012), students from the Human-Computer Interaction course, from the Computer Science degree, developed an app for the definition of the architecture functional programme for a house, according to family profiles. The app enables the user, either a single person, a family or any other combination, to get a functional programme for their house to be defined in an automatic way. The functional programme, based on Portuguese literature and housing legislation, includes data on the required number and type of rooms, as well as on the connections rooms are recommended to have with each other. The user introduces data on the co-habitation group, like ages, gender, fam-

Figure 11. Design solution achieved by the use of shape grammar, floor plan of 2nd floor
Source: Ferrão, 2013.

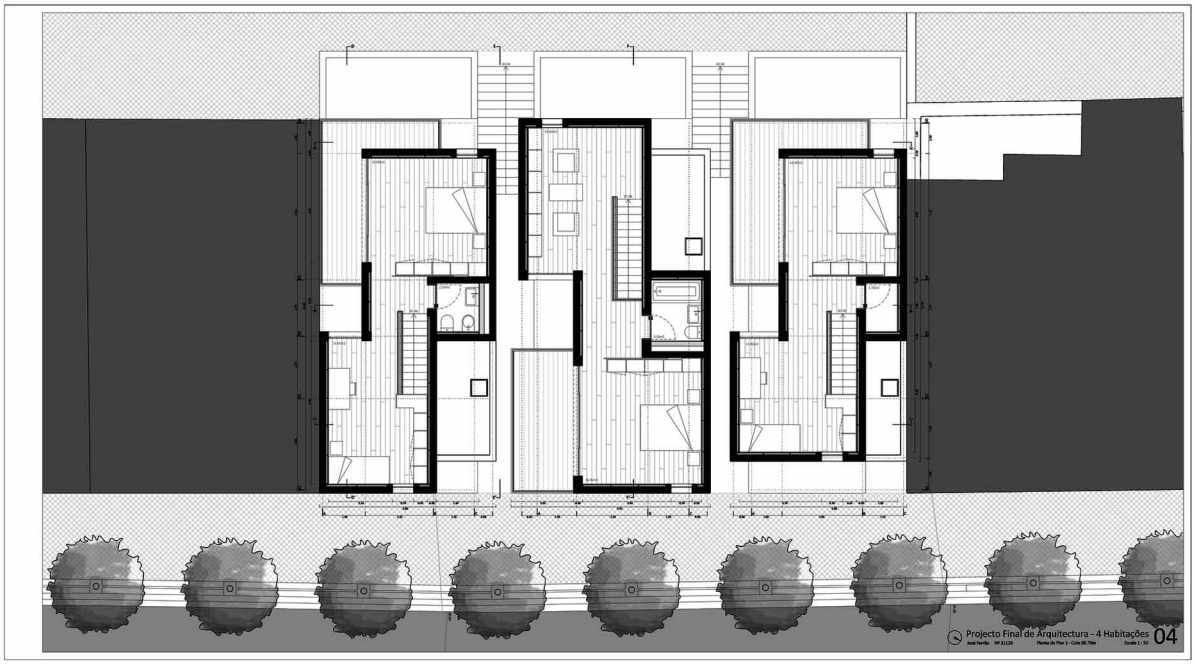
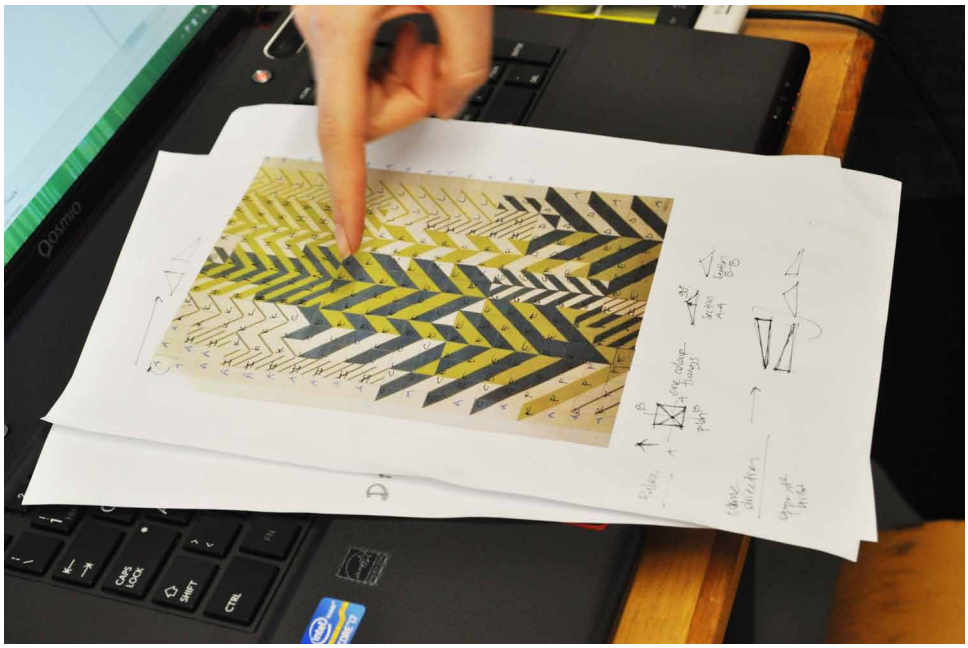


Figure 12. Work session at the workshop "re-inventing ceramic tiles using shape grammars as generative method for pattern design", Future Traditions eCAADe Regional, Porto, Portugal
Photo: Sara Eloy, 2014.

Figure 13. Interpreting a ceramic tile pattern at the workshop "re-inventing ceramic tiles using shape grammars as generative method for pattern design", Future Traditions eCAADe Regional, Porto, Portugal
Photo: Sara Eloy, 2014.



ily relationship and existence or not of a disable person and the software gives as an output a list of spaces and connections that respond to that cohabitation group (Figure 14 and Figure 15).

The requirements for the app come from Eloy (2012) and the process of developing the app implementation included several meeting between architects and computer scientist, professors and students, in order to redefine and debug the assignment requested. Through this multidisciplinary work, is was possible to test both to students and researchers the difficulties of developing an app for a real client/context.

The app, for now working on the Android platform, was developed over a period of 5 months. A "low fidelity" approach (Rettig, 1994) was used to start the project, utilizing user tests early on, starting at the interface and interaction process definition, and along its different stages of prototype development. Direct observation of the app being used, users' evaluation and users' feedback, enabled successive interface and interaction refinements for a better final app prototype.

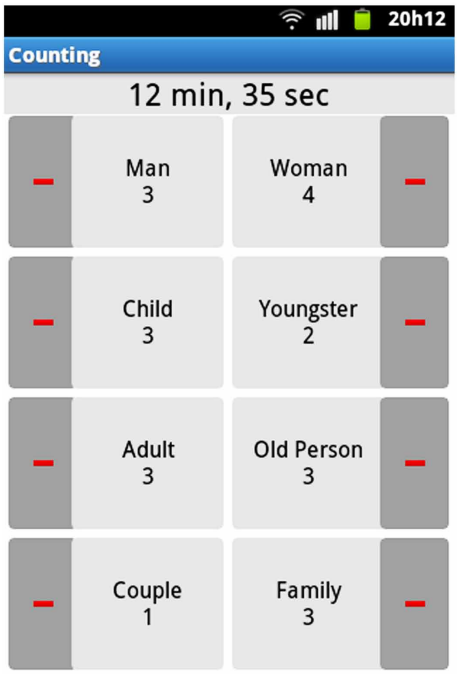
Data Collection

According to Montello (2014), architecture influences human cognition, experience and behavior since it allows, facilitates, requires or prevents human perceptions, thoughts, emotions and acts. Our research goals are to understand and map human emotions, spatial perceptions and reactions, when moving in architecture spaces. To do so, several techniques have been use and a joint multidisciplinary work has been developed between Architects, Computer Scientists, Video Game specialists, User Experience experts, Psychologists and Ergonomists.

Studying the use of space requires time and the application of both observation techniques and powerful data collection and analysis tools driven by new technologies. In this framework, our

Figure 14. App House generator, starting interface with the possibility of choosing a standard (typical) co-habitation group or personalizing it (custom)

Figure 15. App House generator, interface to introduce data on the co-habitation group



purpose is to assist the development of methods to study the social impact of build environments from the users' perspective. These methods include automatic and semi-automatic systems for capturing, monitoring and analysing data about how people use buildings and public spaces, as well as models for mapping space use patterns.

For specific studies it's not possible to use the real environment since e.g. the goal is to observe people behavior with and without certain space characteristics (which are the "independent" variables of the experiment), or to study a design proposal. In such cases, the observation of the built environment through its simulation in full and semi-immersive VR systems, allows us to highlight or hide the space characteristics we intend to study and to enable the user's experience to be in a the full-scale space. The use of VR environments, constitute an observation technique that enrich the way students research about the social impacts of their designs and enables the reframing of design solutions according to the outputs of the analysis. When studying an existing space, local observations are mandatory and they combine several empirical visits to the place, where students/researchers randomly photograph and register the behaviours of the people passing through or staying at the places. Time-lapse film techniques as well as observations from fixed places (behaviour mapping and counting) are some of the observation techniques adopted by our team and used in real spaces (Vaughan, 2001; Whyte, 1980). The observation results enable us to map what occurs in space so that, through an evaluation process, we can assess the potential of a specific place to be successfully used and the importance of its configuration in shaping its envisaged social life.

Besides the adoption of semi-immersive VR systems, such as the PocketCAVE previously mentioned, the use of an "egocentric" full-immersive system, such as with the Oculus Rift HMD, allows students to observe and register end-users' behavior in simulated situations adjusted according to

their research goals. Through these technologies aids, students are able to test their design solutions in real-life scales, as if they were already built in real contexts, providing the users with a freedom of movements similar to those they would have had in the real world. With this, higher degrees of immersion and presence are achieved, producing behaviors that are similar to the ones users had during real world interactions.

Time Lapse

Time Lapse film, video and photography techniques, have been used in several areas to study slowly evolving phenomena, in Biology (plants growth and behavior; underwater and deep sea animal behavior), Chemistry (slow developing reactions), Weather studies (cloud formation and development; glacier dynamics and icebergs formation) (Bongaerts, 2014; James, 2012; Lopes, 2014b). As a rule, the areas of study where normal/real time observation is not well suited for the data acquisition at hand, can benefit from applying Time Lapse acquisition and processing techniques. The fine time compression setting that Time Lapse enables, with control on the time compression ratio, amplifies its value and use: image capture can be set in different time intervals, from 1 second to hours or days, depending on the phenomena or event being studied. Once the record interval is established, it is fixed and used in one full complete Time Lapse recording. This interval is defined for each case: clouds evolution, depending on wind speed, can be recorded in 5 to 15 seconds interval. Recording a complete building being built, from its foundations up to completion, can be recorded in 24 h intervals. Studying the space (a street, a roundabout, a public garden or plaza, an interior in a building), being used, crossed, traversed by people can be done with 3 seconds interval or more, depending on the time compression needed. This information can then be used as input to a space analysis process, in combination with other techniques, like counting and tracking or Space Syntax (addressed in the next sections).

The relevance of Time Lapse in terms of making it useful in real life applications, is to teach students the "how to" use the available equipment to maximize the results. Today, film is too expensive to be used for Time Lapse recording. This rules out cinema cameras and photography cameras based on film recording. Video capture is an option if power constraints are met: either the video camera or the Time Lapse video control are self-powered and autonomous for a large period of time (and this is rare), or the main limitation is to find a usable place where a power energy source is available. Indoors use, present no problem since access to the power grid is pervasive, but outdoors use can be quite limiting.

This leaves digital photography as the current "Holy Grail" of Time Lapse recording. But specific knowledge needs to be taken into account, or the expectations digital photography raises can very rapidly turn into low quality results or short lived recordings. Technical relevant details paired with digital photography techniques are explained in our curricula, with fundamental theory and practical demonstrations backup. Battery energy optimizations and Time Lapse use maximization strategies are explained. As a result, Architecture MArch thesis incorporate work done with Time Lapse outdoor capture, for instance seen in Romão (2013, p.168-169, 200-201), successfully mastering the acquired knowledge.

Counting and Tracking People

In the scope of needs gathered from courses on urban planning and space analysis with space syntax, a counting app, for Android smartphones, was developed by students of the Human-Computer Interaction (HCI) course, from the Computer Science degree, to facilitate counting when doing local observations. Instead of using a sheet of

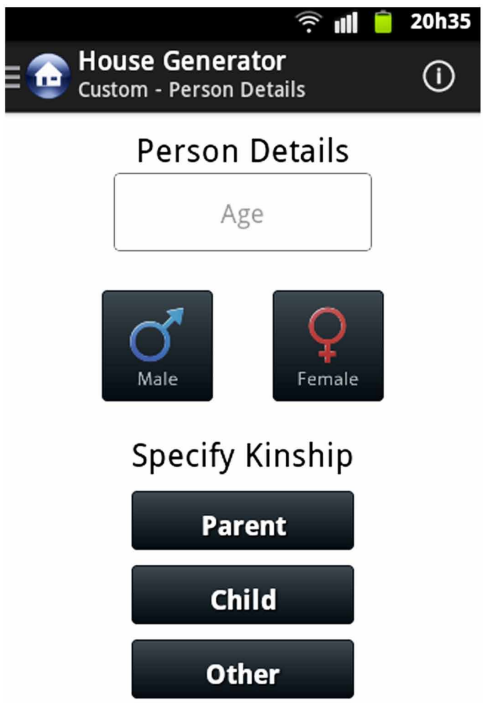
paper, observers can use the app for more efficient counting of people/transports and the creation of automatic reports that saves time and avoids mistakes (Figure 16 and Figure 17).

Counting people is one observation technique used when we want to learn about the environment without taking account of people's intentions (Vaughan, 2001). The developed app enables to perform the Gate Method counting (Vaughan, 2001, p. 3), which can then be used to represent graphically and statistically the record numbers of moving people or vehicles that have passed through a gate or gates.

One difficulty Computer Science students have, is to understand and how to address users' needs and user centered specifications. To develop awareness and foster better learning results, user centered development approach is used in the HCI course, along with a "low fidelity" (lo-fi) development methodology (Rettig, 1994). This approach, along with real life situations involving students in real life projects and needs, such as the counting app, produces visible and usable results: in the app development, students from both the HCI and Architecture courses worked together and learned, on one hand, how to address the client's needs, interact with and understand the client's language and specifications and, on the other hand, how to define the requirements, test and evaluate the prototypes being created in successive interactions, working in a multidisciplinary team. During the development phase, several different Android smartphones were tested to ensure cross platform/manufacturer uniformity of graphical interface and interaction. Usability tests were conducted with architecture students and professors. The app is now being used in architecture courses by groups of students, as well as in research done in the scope of MArch thesis and will be, in the near future, used by students of psychology.

Figure 16. Counting app, start screen

Figure 17. Counting app, one counting example



Tracking people's movement is another observation technique that enables to investigate about patterns of movement from specific locations, the relationship between routes in an area, and the average distance people walk from specific locations (Vaughan, 2001; Whyte, 1980). Instead of using a traditional plan of the area where researchers trace the routes people are taking as they follow them, several technics have been developed, from the more manual ones (Dalton, 2012), to the ones that automatically detect and track people (Ramanan, Forsyth, & Zisserman, 2007; Kuipers, Nunes, Pinheiro, Tomé, & Heitor, 2014; Mittal & Davis, 2003).

Eyetracking technology is very useful to study visual attention and eye movement and is an interesting approach to examine the influence of environmental cues on space use (Schütz, Braun, & Gegenfurtner, 2011). In line with recent studies about environment perception and use (e.g., Noriega, Vilar, Rebelo, Pereira, & Santos, 2012; Wiener, Hölscher, Büchner, & Konieczny, 2011), our team also believes that gaze direction, fixation and visual exploration patterns can be important predictors of space use. When doing local observations, both in real and virtual space, we use the Dikablis Eye Tracker from Ergoneers to track users's gaze, fixations and saccades along their path. This device allows us to collect eye fixations and saccade movements that are complemented with manual tracking for additional detail on subject path, visual attention points and landmarks.

Tracking people is an observation technique architecture students use to analyze social behaviors in the space they are designing for or researching about. Students also use tracking observation to compare between behaviors in different situations, both in real or virtual spaces, varying specific variables as, e.g., with or without environmental sound as we'll explain later in the Evaluation section. Research in this field is being developed considering that visual attention could be connected with sound perception, influencing the users' movement in a given architecture space.

Emotions

For a long time the relation between the activity of nervous autonomous system and emotions have being studied as well as its representation in digital systems (Muass & Robinson, 2009; Kreibig, 2010; Peter & Herbon, 2006). Following this line of research, we are exploring the use of biometrics sensing technology both in real space and within a semi-immersive VR environment, where users face architectural spaces which will induce them sensations, such as confort (Dias et al, 2014a) or fear (Dias et al, 2014b). Users' physiological data is collected through electromyography (EMG) (Figure 18) and electrodermal activity (EDA) sensing (Figure 19) aiming at detect users' emotional arousal while moving in space (Figure 20). To complement the obtained automatic responses,

Figure 18. Electromyography sensors placed on a subject participating in a VR experiment, before the start of the experiment

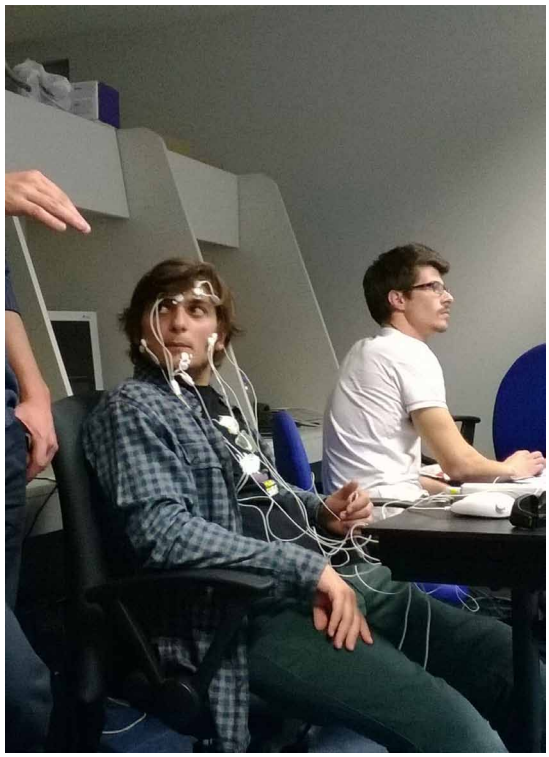


Figure 19. Electrodermal activity sensors placed in an experimental subject during an experiment in VR

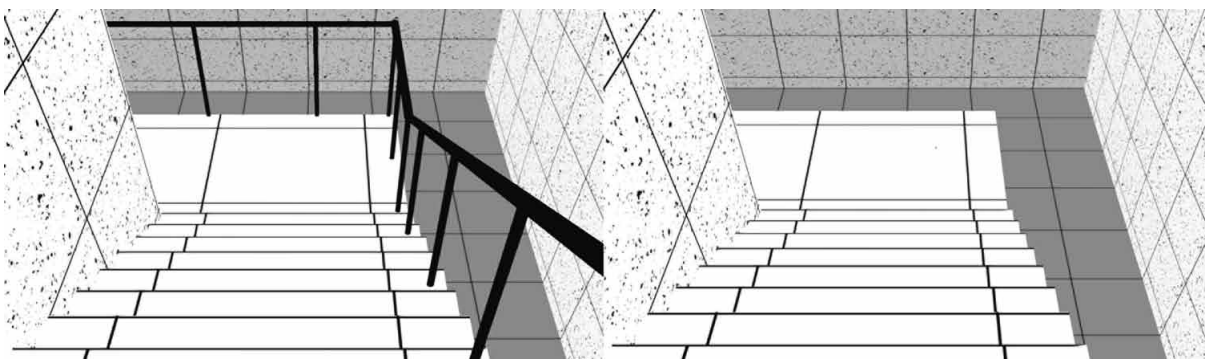
we use questionnaires that give us the controlled perception. These measures can give designers basic information on people's emotional state when using the buildings they design.

The development of all these observation methods and mapping instruments, allow us to map the behaviors and emotions people have in space to reach patterns of behavior related to space characteristics. Instead of defining a typology of spaces, we want to propose a typology of experiences users have in spaces.

Evaluation

The evaluation of buildings and public areas performances regarding specific criteria, is a well establish practice nowadays assisted by several methodologies and analysis software. In fact, the relationship between building operation targets and user well-being in the built environment, has driven the development of effective design methods centred on users and responding to their requirements. Simulation, prediction and evaluation methods are addressed by the use of particular solutions and methods. Research about people's behaviour in the building environment by using technological methods to evaluate its potential, is being developed in our School in the scope of a Space Syntax and Complexity course, in Msc and Phd thesis, with applied research in topics such as objective assessment of emotions in immersive VR and (Dias et al., 2014a, Dias et al., 2014b).

Figure 20. Virtual representation of an indoor space, depicting a stairways passage, with (left) and without (right) railings, used for an experiment to study the fear of fall expressed by elderly.
Source: Dias et al., 2014b.



Space Syntax

The use of space syntax analysis allows architecture students to evaluate the potential and limitations of any space configuration and interpret the relations occurred between space and society, according to the principles set out by Hillier and Hanson (1989).

Space syntax proposes a quantitative analytical methodology, where the space is defined by a set of syntactic measures, based on mathematic formulas, with the goal of understanding how the formal characteristics of a space and its relations with the rest of a system affects social experiences. In addition space syntax aims to be both a descriptive tool, allowing us to understand the operation of existing social structures, and predicative, allowing to evaluate the performance of proposed scenarios (e.g. Hanson, 1984; Hillier & Hanson, 1989; Hillier 2003).

In design studio, students that are already familiar with space syntax methods use it to analyse existing urban morphologies and understand their development through time or a particular phenomenon of urbanity (e.g. the gated condominiums by Lopes (2013) or the opening of the inner yards of urban squares by Romão (2013)). Informing a design with space syntax analysis, enables students to explore different design solutions and evaluate them in accordance to the requirements they are looking to fulfil. Always with an approach of complementarity to their own design methodologies, students use space syntax analysis, as a method to quantitatively evaluate their proposals and with that data take more informed decisions.

Patterns of Behaviour

For several years now the interest of applying Space Syntax as a complementary analysis tool to Spacial Cognition, has been explored in the research comunity. In recent decades and with the emergence of Virtual Reality, we´ve witnessed an integration of this tool in the analysis performed by Space Syntax. Today the combination of both techniques (Virtual Reality and Space Syntax), to address research on Spacial Cognition, namely on Wayfinding, represents one of the important aspects of this theory development (e.g. Dalton & Holscher, 2006; Meilinger, 2006).

A VR system like the PocketCAVE, allows to have users experimenting the interaction with a virtual environment and feel as if they were present in the scenes, therefore enabling researchers to evaluate spatial characteristic and designers to act according to the output data.

In the experiments already undertaken, which involved a large number of participants, statistics control methods and objective and subjective assessment techniques were used. The objective assessment is given by the use of non-invasive Electrocardiography (ECG) sensors and Electrodermal activity (EDA) sensors. Subjective assessments include properly structured questionnaires (Pre and Post Test), and were done in a close cooperation with Psychologists by means of retrospective questionnaires. For one of the experiments, Dias and colleagues (2014b) investigated the fear of falling reported by older users while interacting with architecture spaces considering a VR-based methodology. Architecture spaces composed by stairs, ramps and neutral rooms were arranged in order to create a virtual indoor space. Two experimental conditions were considered, a safe condition in which handrails were placed on stairs and ramps, and an unsafe condition, in which handrails were removed (Figure 20). ECG and EDA were collected during the entire interaction and at the end of the experiment, the Implicit Association Test (IAT) was applied to measure associations between concepts that often reflect an attribute (Greenwald, McGhee, & Schwartz, 1998), in this case, the strength to which a person holds an ageing stereotype. Main results concluded that there are heart rate acceleration and higher electrodermal activity, that can be associate with the fear of falling, when comparing the neutral room with the top of a stair in both conditions

(safe and unsafe). Participants also reported higher perceived fear for the unsafe conditions. IAT results shown that the unsafe condition seems to increase the ageing stereotype. According to Levy (2003), the representations that older persons have about their age group, negatively influences their behavior. This author has shown that negative ageing stereotypes are related with the decrease in walking speed, worse memory performance, greater physiological stress and less will to live. In this way, attained results make clear the high impact of architecture elements on users' performance and well-being. For this study, students and young researchers from computer science, architecture and psychology could interact with each other to develop a multidisciplinary experimental research, developing and expanding their scientific expertise.

We are especially interested on how other stimuli in addition to the visual one, affects people's perception of space. To study these phenomenon, we are conducting a multidisciplinary research experiment on how various sounds in real and VR environments, affects architectural space perception and use. This experiment aims to study the perception of space with environmental sound/noise auralization and the relation between users' movement in space with and without sound. The results of this experiment will be correlated with space syntax outcomes on the potentialities of the tested space. The experimental setup-up will be in the semi-immersive stereoscopy VR environment and we will use full 3D auralization, stereoscopic vision, eye tracking, EDA and ECG sensing, 3D user tracking in the environment, Kinect One sensing (Heart Beat rate via vision, speech input) and speech output.

Representation

Advanced representation procedures and the development of more efficient visualization systems, constitute areas of research closed related to practice and education and in which the joint work enable to achieve results that may be immediately used by students.

At a first stage of design, students develop their ideas partially sketching with manual tools exploring space, light and textures (Figure 21). Realistic image renderings are used at later stages in order to reproduce rigorously all the features of the designed buildings, enhancing materials, illumination and space itself (Figure 22).

The technologies addressed in the previous sections have been also developed to enhance the representation of architecture in the final stages of the design process. For this propose the described VR app, VIARmodes, includes a Realistic Model which aims to achieve a more photorealistic visualization enabling the designers to add textured environments, as well as present it to the client or other stakeholders. In the satisfaction test performed to evaluate the app, the Realistic Model was considered mainly relevant to the communication and presentation of the project between the architecture team and meetings with the client (for 30% or the surveyed) (Coroado, 2014).

The representation and exhibition of already existing architecture and urban settlements has brought us the understanding of design processes, building technologies and cultural believes that inform nowadays architecture. Several authors have use digital technologies in order to enhance the knowledge about past cultures and architecture through a better visualization using immersive virtual reality (Ibrahim, Jahnkassim, Ali, Latip, & Abidin, 2007; Zara, 2004; Campagnol, Clayton, Caffey, Kang, & Glowacki, 2014) and augmented reality (Noh, Sunar, & Pan, 2009) in heritage studies or in architectural curricula. Virtual and augmented reality and animation tools are used to study architectural and constructional details and relate them with the social structure of the time. The possibility of doing a walkthrough and

Figure 21. Sketches of a design proposal
Luís Coroado.

Figure 22. Realistic rendering of a design proposal
Luís Coroado.

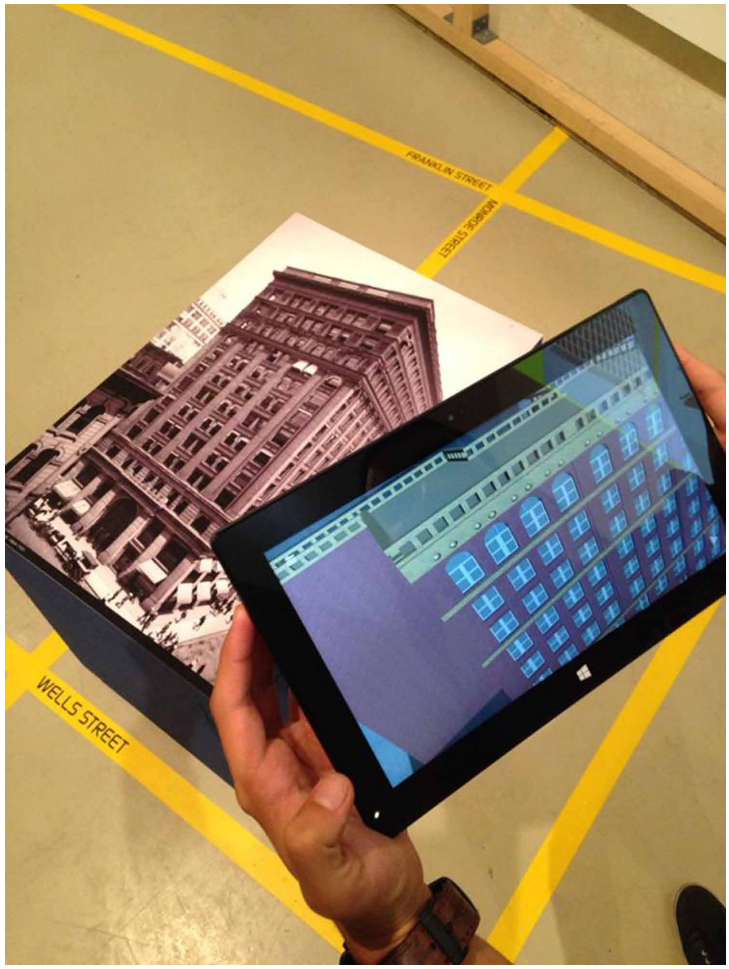
decompose buildings and cities' models into e.g. layers of time periods, enable a broader understanding of how societies live at certain periods in the history.

We want to use digital technologies to show a specific type of architecture and building construction, in an interactive way, that could allow users to have more information than they would have with traditional physical model building or traditional drawings. For that propose the digital technologies developed at our school are used as a link between History and Building Technologies in order to develop a complete digital exhibition in which the digital technologies would enable to inform visitors, in an unexpected way, by allowing them to interact with the exhibit architecture. In 2013 we developed an educational innovation joining several courses around a common theme - "School of Chicago: Digital Skyscrapers ". Our aims was to display and revel the architectural culture of the final period of the 19th century to the first decades of the 20th century, by enhancing the historical knowledge as an active tool in today's digital universe.

This work ended in an exhibition focused on the deployment of paradigmatic skyscrapers in Chicago, allowing multiple radiographic looks through the use of digital technologies. Our pocketCAVE was moved to the exhibition room allowing visitors to freely navigate through a simple 3D model of the streets of Chicago (Figure 23). Urban morphology was drawn in the room floor at scale 1:75 and some buildings emerged from it to be used as containers to Augmented Reality and 3D video mapping experiences. In the exhibition, two Windows tablets running the ARch augmented reality app, enabled AR interaction of the visitors with 3D models of some of the buildings, enabling the frame structure and the architectural elements to be visualized (Figure 24). With these models visitors could explore the buildings by showing or hiding some parts of the model or computing

Figure 23. 3D model of Chicago in the PocketCAVE
Photo: Hugo Cruz, 2014.

Figure 24. Augmented reality app showing one of the Chicago's buildings
Photo: Christine Trevidic, 2014.

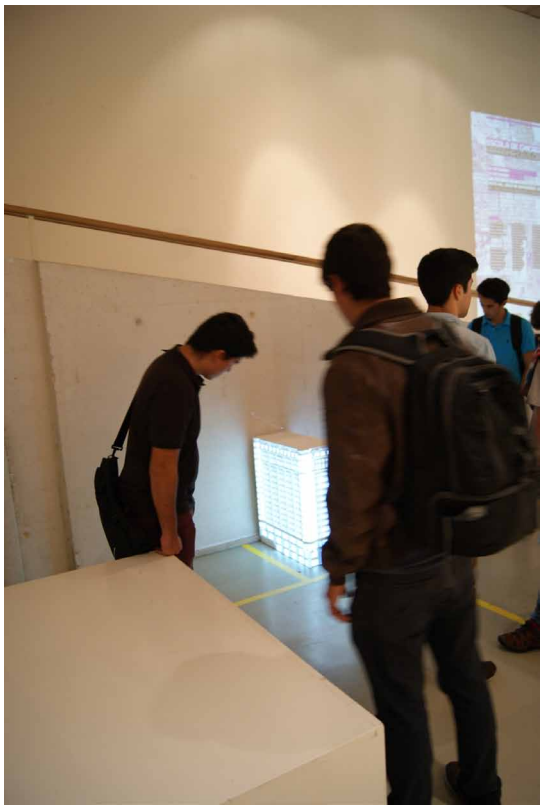


sections in real time. 3D video mapping was used to explore the potential of this technology in architecture exhibitions. For this technology, two projectors were used to enable the projection on four elevations of the building (Figure 25). The use of 3D video mapping was studied in the scope of two master thesis, one with an application in architecture exhibitions (Figure 25) and other, as a tool to be used in the design process (Figure 26). Velhinho (2014) developed an app that enables the projection of different modes of representation allowing the user, with a keyboard, to shift between them in an easy way in order to obtain several types of visualization of the building: textures, dimensions, insolation, sections, floor plans among others that can be created.

All technologies and contents of the exhibition were produce by bachelor, master students and Phd students, of Architecture and Computer Science courses, in a joint collaboration to empower research in early years of the architecture programme.

At the end of this exhibition visitors were asked about their opinion on the advantages of using digital technologies to show architecture and if these technologies enable them to better

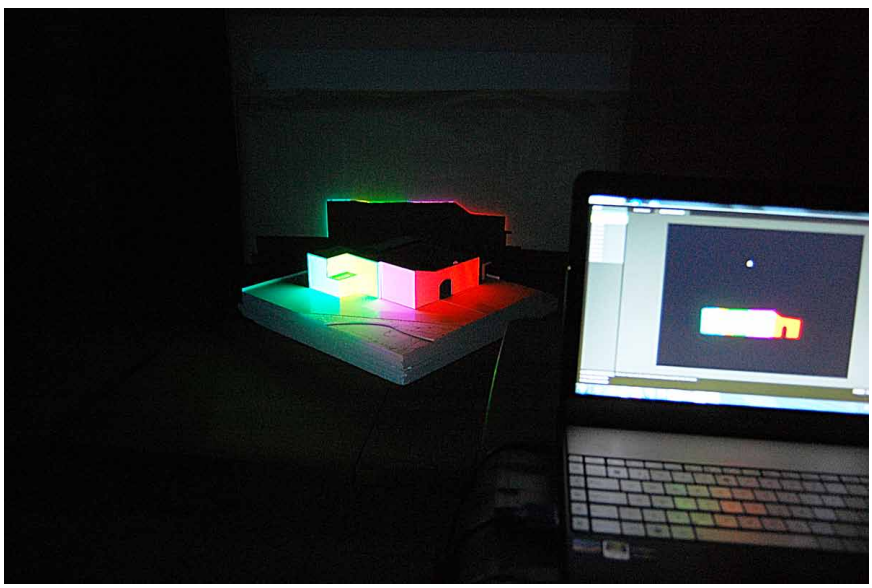
Figure 25. 3D video mapping over one of the Chicago's buildings
Photo: Sara Eloy, 2014.



understand architectural design. From a group of 25 surveyed, 44% totally agreed and 32% agreed that 3D video mapping helps the understanding of a building in an architecture exhibition. For the ARch app, 13% of the users said that the available options at the app enable a very good understanding of the building and 36% rate it as good. When asked if the digital tools used in the exhibition where able to add more clear information to the users in comparison to traditional architectural exhibitions, 36% of the users ranked it as very clear, 36% as clear and 28% as neutral.

An elective course on Sound and Video for Multimedia is offered to students. In this course, technology on digital sound and digital video is taught along with topics and techniques on developing a Title, Storyline, Storyboard and Planning to produce and direct a video project that tells a story and captures the targeted audience attention, applying in the way the grammar of the audio-visual (video) language. The areas of application of the acquired skills can be put to use whenever and wherever a time based visual and sound media (narrative video built or acquired observational

Figure 26. 3D video mapping projected onto a scale model of a building and application interface.
Source: Velhinho, 2014.



video data) is usable: the main objective is to give students the mastering of another expression tool, the digital audio-visual speech.

DISCUSSION

The simulation of real spaces in VR settings allowed us to evaluate several parameters of a built space, which in any other representation manner would not be possible. The simulation of space use and the consequent evaluation done during the architecture conception phase, influence the the decisions undertaken during design process, allowing to reframe design and correct the identified problems. The introduction of three-dimensional immersive visualization, by systems like the CAVE, in the usability assessment of the built space, complements the evaluation currently performed by digital CAD tools which run over bi-dimensional representations of such space. Thus, possibilities brought by the CAVE environment combined with the multidisciplinary research under development, are empowering students with new tools for design, based on more informed decisions.

The digital skills we are using and developing with students and researchers, have been well integrated in the architecture curricula and the progressive acquisition of IT knowledge through the years, via close cooperation with the Computer Science department, its researchers and students, has enabled architecture students to learn how to integrate computers skills in design tasks. In the last year of Master Graduation in Architecture, students are proficient in using digital design tools and their use is now volunteer, rather than imposed or suggested by professors. With this background, several Master students opt to develop their master thesis in subjects related to the use of digital design tools in order to transpose the user perspective to the developer of CAAD software team and a few of them, decide to pursue further research of novel multidisciplinary areas of integration of Computer Science and Architecture, in the scope of Phd programs at ISCTE-IUL.

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KEY TERMS AND DEFINITIONS

Biometrics: Process of measuring and statistically analyzing human body data characteristics.

Data Collection: Set of techniques that allow gathering and measuring information on certain variables of interest.

Design Evaluation: Set of theories and techniques that enable the evaluation of design solutions according to several variables.

Design Process: The methodological stages used to develop a design. Stages are connected, can be subdivided and based in specific techniques.

Generative Design: Design method that creates design solutions through rules or algorithms.

Shape Grammar: Generative design system that analyses and generates designs through computations with shapes.

Space Syntax: Theory and a set of techniques that enable to analyze space and its social effect.

Section 4

Pre-Degree Valuable Studies

Chapter 18
The Importance of Virtual Learning Environments in Higher Education

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ABSTRACT

This chapter focuses on the concept of virtual learning environment (VLE), its characteristics and potentialities. We present the results of a research work conducted with a sample of 347 undergraduates from a Portuguese public higher education institution. The research addressed the issue regarding the use of virtual learning environments within the higher education context and had the following aims: identify the VLE access frequency; assess the influence of users' computer skills on the VLE access frequency; and assess the importance and impact that students consider the VLE to have on supporting the course units they attend. In the light of the results obtained and considering the VLE used in the sample institution, we highlight that the majority of students accesses the VLE on a daily basis, no significant differences were found regarding VLE access according to users' computer skills, and the most valued aspects of the VLE were: checking exam results and receiving teachers' messages or notices.

INTRODUCTION

Virtual learning environments (VLE) have become increasingly more important within the context of higher education, mainly due to the tools which compose them and to the support they give to students, teachers and institutions.

This chapter focuses on the issue regarding the use that undergraduates make of virtual learning environments to support the teaching and learning process. Emphasis is given to the assessment made by students of certain aspects of virtual learning environments.

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Considering the quantity and diversity of digital resources available in this era immersed in technology, we think it is highly important to research on the use that undergraduates make of virtual learning environments in order to assess their use frequency as well as the value and impact they think VLEs potentialities have in the development of academic activities.

This research work assumed approaches close to both quantitative and qualitative research.

The research questions underlying this study intended to find out how frequently undergraduates access virtual learning environments, to assess whether or not users' computer skills influence their access frequency to virtual learning environments, and also to assess the impact and value that students assign to VLEs and to the tools which compose them. As far as users' computer skills are regarded, students were classified in three independent categories associated respectively with basic skills, intermediate skills and advanced skills.

Virtual learning environments have altered the relationships between teachers and students as well as between these and the whole school community regarding access to information and resources. According to Ellis (2009), such environments must include, among others, characteristics of centralization and automation of administrative procedures, use of services oriented to users, reduction and distribution of contents, consolidation of training initiatives, personalization of contents and reuse of knowledge.

By administering an online questionnaire to undergraduates, we were able to identify, among other aspects, the frequency, value and impact given to the use of information and communication technologies (ICT) within course units, the value given to the characteristics of digital resources associated with the Sakai environment, and the value given to the availability of digital resources in that same environment.

The use of ICT in education leads to learning contexts more centered in the learner, which often leads to some changes in the way teachers and students relate to each other. However, considering the fast evolution of digital and information means, the role of ICT in education is becoming more important day by day, and such importance will continue to grow and develop throughout the 21st century. Therefore, in higher education, not only are ICT a technique used for educational development, but they also represent a nation's way to socio-economic development (Sarkar, 2012).

ICT have enabled a real revolution in almost all areas and dimensions of the human being. Within each area of activity, ICT have assumed different roles, including that of a communication and interaction tool between people as well as between the latter and organizations.

Virtual learning environments stand out as elements which have organizing features and which condense a big part of the teaching and research activity within higher education, generally representing a coherent whole involving multiple dimensions. Within such dimensions, particular focus was given to the use and value of the digital tools that VLEs contain. In an attempt to understand the value assigned by students to VLEs within the context of higher education, a study was conducted aiming to contribute to answer the following questions:

- How often do higher education students access virtual learning environments?
- Do users' computer skills influence their access to virtual learning environments?
- What value do undergraduates assign to virtual learning environments and to the tools which constitute them?
- What impact do undergraduates consider virtual learning environments to have on the support to course units?

The answer to these questions may help justify options of ICT use and adaptability to the educational goals of higher education institutions. As Naveh, Tubin and Pliskin (2010) point out,

understanding the way organizational factors relate to the use and satisfaction of VLEs may help academic institutions to achieve higher return on investment regarding these environments. By knowing the access and use frequency of VLEs as well as the value students assign to them, it becomes easier to define policies of VLEs use within higher education institutions as well as to implement the features most valued by students and teachers.

Virtual learning environments represent essential elements within the academic community of each institution, especially higher education institutions, namely as far as aspects associated with teaching, learning, research and management are concerned. According to Pulford (2011), VLEs are computer based online learning environments which are becoming increasingly more common in universities and can provide learning resources as well as discussion forums where students can interact online with each other or with teachers.

The concept of VLE is quite complex due to the dimensions it involves and to the emphasis given to such dimensions. Any learning environment includes the people who use it and interact or cooperate within its context. However, besides these, such environments also include dimensions such as time, space, and the resources and strategies which can be implemented in the teaching and learning process.

Overall, virtual learning environments' main feature lies in the provision of tools enabling the support to the production and dissemination of contents, synchronous and asynchronous communication, cooperation and assessment of the teaching and learning process. Other features associated with VLEs include: users' management and record, provision of resources and training activities, checking access to the VLE, control and monitoring of learning processes, evaluation, management of communication services such as discussion forums and teleconferences, creation of its own contents, aggregation functions, and management of contents created in different sources and contexts.

According to Bri, Garcia, Coll and Lloret (2009), VLEs represent the future both within higher and secondary education, they are used by universities all over the world and are constantly being improved and upgraded with new potentialities. Not only are they used in the management and distribution of resources, but they can also incorporate other functionalities associated with students' interaction with each other and with teachers, thus enhancing innovation within the teaching and learning processes of educational institutions.

Virtual environments allow teachers and students to meet and share many of the main aspects regarding the teaching and learning process, which is why VLEs are increasingly more valued within the 21st century educational context.

The importance given to VLEs and internet use has increased over the last years. In a study carried out by Miranda, Morais, Goulão and Melaré (2012) with a sample of 147 undergraduates, the authors concluded that the majority of higher education students use the internet every day, especially at home and at university, to look for information, for educational purposes, to communicate, to work, and as a way of entertainment.

Although this chapter focuses on the use and assessment of VLEs by undergraduates, there are some aspects associated with teachers which cannot be ignored as they may condition students' use.

Adherence to VLEs is not always embraced by all potential users. Firstly, there is a usual resistance to innovation as it imposes a change in habits and routines which have been repeated throughout years. Secondly, it is not easy for teachers to get out of a comfort zone where they feel safe and with consolidated pedagogical knowledge into a zone of experiences and expectations which lead both teachers and students to face new scenarios

whose results are often unknown. This idea is reinforced by Sánchez and Alemán (2011), who point out that teachers' perception of changing teaching and learning strategies when adopting e-learning is directly related to the greater effort they are obliged to make when developing digital contents.

In order to reduce teachers' difficulties regarding the use of VLEs, Wang and Wang (2009) suggest that it is crucial to identify the factors which limit their use so that the institutions' decision makers can be influenced to define policies leading to the adoption and development of those environments.

Therefore, this study was developed within a Portuguese public higher education institution where the Sakai collaborative environment is used. This environment, which will hereafter be called Sakai environment, is used in the support to teaching and learning of the course units which compose the degree courses developed within the institution.

In this chapter, we present a conceptual framework of VLEs as well as their features and potentialities. Also, we present the results and methods of the study viewing to achieve the following aims:

- Identify access frequency to the digital resources provided in the VLE;
- Assess the influence of users' computer skills on the access to the virtual learning environment;
- Assess the value assigned to the digital tools which constitute the virtual learning environment;
- Assess undergraduates' perceptions regarding the impact of the VLE on the support to the course units they attend.

CONCEPTUAL FRAMEWORK, METHODS, AND RESULTS

Virtual Learning Environments

Virtual learning environments have been gaining greater relevance in all levels of education, especially in higher education. They assume a wide multiplicity and diversity of dimensions and can be explored and adapted to innumerous teaching and learning contexts. Therefore, they enable teachers, students and institutions to open new perspectives regarding the construction, dissemination and use of knowledge grounded in current research and pedagogies which take into account the interests of the educational community and what society expects from it as well as ICT potentialities, namely those associated with virtual learning environments.

The concept of learning environment was for many years associated with a physical space integrated within an institution and a specific timetable in which the teaching and learning process took place. Such process was teacher-centered and made use of strategies focusing on reading, listening, explaining and memorizing, leaving a low participatory role to the student. As referred by Piccoli, Ahmad and Ives (2001), learning environments are traditionally defined in terms of time, place and space.

The change from a traditional teaching paradigm into VLEs supported teaching was originally still highly centered on the teacher, who made digital files available to students through personal webpages, which represented a very low interaction between the teacher and the student. Later, powerful synchronous and asynchronous communication tools were gradually introduced, thus giving students an active role in the interac-

tion which can be promoted between students and teachers as well as among students themselves.

VLEs represent flexible educational spaces which are simultaneously resource centers and means of information and communication which provide teachers and students with conditions to work together and interact synchronously and asynchronously, in a bidirectional or multidirectional way. As referred by Alves, Miranda, Morais and Alves (2011), access to information and knowledge has become a crucial factor to the change of economic and social structures, representing the key to competitiveness and innovation in a world increasingly more global.

Digital resources have brought about a change of the learning environment concept, namely regarding aspects related to geographical location and physical and cultural boarders, leading to the appearance of new concepts of learning environment.

VLEs have had several designations throughout their creation and evolution. Among these is the learning management system which, according to Bri et al. (2009), consists of some software installed in a server with the purpose to manage, distribute and follow the activities which support teaching, on-site training and e-learning within an institution. Among others, the main functions of a VLE are: manage and register users, provide training resources and activities, check access, control and monitor learning processes, assess and manage communication services such as forums and teleconferences.

Although the majority of VLEs are used to manage and distribute resources, they can also include other functionalities to support students' interaction with teachers and with each other, thus enabling the creation of opportunities to a greater innovation regarding the teaching and learning processes within educational institutions (Lonn & Teasley, 2009).

As far as VLEs functionalities are concerned, Reigeluth, Watson and Watson (2011) suggest that among others, they should include functionalities regarding the record of students' learning, the planning of teaching and learning activities and the assessment of students' learning. The authors add that VLEs should include as secondary functions communication tools, general data concerning students, general information concerning teachers and administration tools.

When characterizing virtual learning environments, great importance is given to aspects concerning the physical separation between their stakeholders and to the communication channel that joins them. However, besides this, great relevance is also given to the strategies related to interaction, participation and cooperation that they can promote between teachers and students and among the latter within the educational context. Thus, we may consider that strategies represent the dimension which enables the dosing of resources, time and space management in order to obtain several levels of emerging elements within the teaching and learning process.

The focus given to cooperation leads to the need to turn learning environments into pedagogical and social spaces of communication, which requires the use of digital resources which provide teachers and students with the appropriate conditions for innovation and collaborative learning. This way, each educational collectivity will benefit from each member's contributions aiming the joint construction of wider and better knowledge.

Considering the complexity and the dimensions that a VLE can incorporate, it is not easy to find a consensual definition of VLE. However, it is essential to analyze and assess several approaches so that each user, namely students, teachers and researchers can explore the part of each approach that best suits their goals.

The concept of learning environment has a rather broad scope due to the dimensions which it involves. Among these, the dimensions regarding space, time, resources and strategies stand out. Thus, we may consider as learning environment any context characterized by dimensions associated with space (social, physical and virtual),

time (schedule, periods of use and availability), resources (material, technological, scientific, pedagogical and human), and strategies (lecturing, participatory, interactive, cooperative and individual work).

Learning environments are spaces where students and teachers can work together and collaboratively, during the periods of time that they want and using the resources that they find more suitable to the tasks that they intend to fulfil. The social spaces where people gather are becoming wider in geographical terms and closer in temporal terms. Similarly, the distance at which people can meet is increasing in physical terms but decreasing in terms of the time needed to establish contact, thus connecting the idea of cooperative work more closely with time than with physical distance. Therefore, the concept of learning environment may be understood according to the strategies used, the resources available, space and time.

VLEs are systems based on the web which enable teachers and students to share materials, submit and return assignments, publish notices and communicate online with each other (Lonn & Teasley, 2009). The use of VLEs helps to achieve efficiency in the development of students' teaching and learning practices (Santos & Boticario, 2007).

VLEs give institutions the possibility to manage their educational resources and to support teaching and learning both inside the traditional classroom and within the systems of distance learning. VLEs survive by means of their recipients' permanent use and may be greatly associated with their users' level of satisfaction (Al-Busaidi & Hafedh, 2012).

Among the various existing virtual learning environments, we highlight the Sakai environment as it represented one of the supports to this study. According to Alves, Miranda, Morais and Alves (2011), this environment uses a modular architecture based on Java (J2EE), which is service-oriented and allows an easy integration within an organizational context. It is composed of tools, components, services and a framework. It provides, among others, the following tools: notices, submission of assignments, schedule, chat, locker, email archive, reports, messages, news, comments, presentations, resources, programs, online test, questionnaires, web contents, wikis, and blogs. It is a system which provides technological resources which support teaching and learning, research and cooperation.

VLEs have become the key point to innovation and to educational change. As referred by Kukulska-Hulme (2012) "time of change" has become a familiar refrain in the speech regarding higher education. The author points out that the evolution of technology and services based on technology will change the audience's experiences and expectations regarding knowledge access and sharing, adding that higher education institutions will have to provide more online learning and contents as well as more efficient tools to find and use those contents.

So that information and communication technologies (ICT) can provide good results, their use must be supported by efficient pedagogical frameworks, which enable the gathering of increasing information, the improvement of its processing and its dissemination to any person in the world (Del Val, Campos & Garaizar, 2010).

In all levels of education, each teacher must try to always provide quality learning to their students. According to Ellis et al. (2009), higher education researchers and teachers who try hard for their students to achieve good learning results can hardly do so without using ICT. The authors point out that it is still difficult to understand what the best way to use ICT may be in order to enable students to get more deeply and intentionally involved in learning.

Nowadays, it is impossible to think of innovation without taking ICT into account, especially the digital resources associated with it.

Digital has revolutionized several concepts as far as education is concerned. Some of the most

positivist concepts such as machine or resource may nowadays be reinterpreted with greater flexibility and complexity regarding interaction, use and potentialities.

According to Duart and Sangrà (2000), digital technologies give us the opportunity to challenge our imagination as well as to enjoy and rebuild it. Okada (2007) claims that, due to its versatility, digital enables information exchange and has an inherent knowledge exchange and simultaneous learning. These are essential elements to contemplate within formal education towards an open and motivated learning as well as towards the use of resources such as open educational resources (OER) for building knowledge in a collaborative way.

As suggested by Yin and Fan (2011), since the beginning of the 21st century, computerization and globalization have changed people's way of living, working and studying to surprisingly fast rhythms, leading educational systems towards internationalization and towards the adoption of personalized environments. The authors point out that within this context, universities and colleges are facing increasingly bigger and stricter challenges as well as a need to innovate. In this regard, the movement Open Educational Resources (OER) is one of the main forces for the promotion of this transformation which will have a deep and long-lasting influence on educational resources and the teaching and learning process within higher education.

Open educational resources are free digital resources of open access to teachers, students and self-learning, which may be used and reused for teaching, learning and research (OECD, 2007). According to Thomas, Campbell, Barker and Hawksey (2012), these resources may include complete courses, modules, books, videos, tests, applications, or any kind of tool, material or technique used to support access to knowledge.

According to Barros (2009), OER build interaction and promote participation as well as the creation of social scenarios and spaces, supporting services which enhance the creation and access to personalized contents. The author adds that besides the importance that each resource has by itself, particular relevance must be given to these resources format and content within the pedagogical context (Barros, 2012). More than ever before, the format in which each resource is available and the diversity of contents that it can help to approach constitute highly relevant features of digital resources and the safest way to integrate them successfully into virtual learning environments.

As far as the use of e-learning 2.0 is concerned, Karasavvidis (2010) claims that students must have a more active and participatory role and take more responsibility and control in their learning. This way, they will become more self-determined, open to cooperation, willing to share and exchange, engaged in taking part in online communities and in building meaning in shared tasks.

The implementation of ICT in an institution must be thoroughly thought up and planned. However, Mahdizadeh, Biemans and Mulder (2008) point out that in many cases, educational institutions do not pay enough attention to issues such as which or why ICT must be implemented.

According to McGill and Hobbs (2008), ICT have increasingly influenced higher education, as they turned from having a supplementary role into being the core of teaching and learning. Thus, ICT represent essential elements to the creation of technologically advanced learning environments, about which Brooks (2011) points out that evidence strongly suggests that, regardless of all other factors, they have a significant and positive impact on students' learning. Schaik, Martin and Vallance (2012) add that technology can and must be applied in a useful way to change students' role, turning them into active participants in their own learning, thus allowing teachers to assume a role of support to students in several modalities. In other words, the adequate use of ICT in learning

environments can provide students with a change from a passive learning model to an active learning model.

VLEs as well as their associated tools provide students and teachers with great conditions for the promotion of dialogue and joint reflection. Conde et al. (2014) suggest that students and teachers use communication means available within their learning contexts to fulfil learning tasks and improve results.

In this regard, Brown (2010) states that there are authors who claim that VLEs have only had a small impact on higher education pedagogy, although they consider them a great commercial success and susceptible to being replaced by Web 2.0. The same author adds that Web 2.0 has the potential to justifiably change the nature of learning and teaching, namely through the creation of learning networks which can challenge the role of traditional institutions more effectively than previous technologies. In a study conducted between 2004 and 2011 which involved undergraduates and 6800 answers, Palmer and Holt (2012) concluded that the level of satisfaction regarding VLEs has significantly increased in all the items assessed.

ICT have the potential to revolutionize the classroom as far as the acquisition of higher skills is concerned. Such skills include the formulation of problems, the construction of questionnaires and the organization, assessment and construction of knowledge. Besides this, ICT also enhance memorization movements as well as a superficial cover of contents (Bonk & Zhang, 2008).

The use of ICT, especially of VLEs and their tools within formal teaching and learning contexts in higher education requires high persistence, knowledge and flexibility. According to Tucker and Morris (2011), the approaches to the operationalization of flexible education incorporate five categories of flexibility: knowledge, time, content, access requirements, and pedagogy. Each program can integrate flexibility elements from each of these categories, which means that any teaching and learning configuration admits to be flexible in some way.

Zitter, Bruijn, Simons and Cate (2011) question the way to create learning environments which can lead to learning, critical thinking, cooperation and regulation of skills which can be used to transfer guided knowledge into learning results. The authors support the creation of environments where learning can take place according to the elements of the environment, based on a continuous scale which ranges from elements specified in the environment to emerging elements.

Technologies supporting virtual learning environments, especially the Web, represent teaching and learning platforms which standardize access to all services available, giving users the vision of a universal and integrated information system (Hueros & Franco, 2002).

The Importance of Virtual Learning Environments

Information and communication technologies (ICT) have altered the way of being and working within the various domains of human activity. According to Fullan (2007), the change of the educational paradigm depends on the way teachers think and do. Among the different domains, we highlight the educational context, namely higher education. The diversity of digital resources is huge, and so are their potentialities and uses. Focusing on the higher education context, we admit that when appropriately integrated within learning environments, digital resources can be easily used and contribute to respond to the challenges inherent to higher education.

The assessment of VLEs importance within higher education involves the collection and treatment of quantitative and/or qualitative data. In the treatment of data regarding this study, we followed methods close to methodologies associated with

quantitative research as well as others associated with qualitative research. Therefore, we present the methods used and the results obtained separately.

Methods

The nature of the study assumes characteristics of both quantitative and qualitative research. The data presented was collected through a questionnaire containing both closed-ended and open-ended questions.

Considering the procedures which were followed, this study assumes characteristics of experimental research through questionnaire, as we conducted an online survey through questionnaire to the respondents of the survey who belong to the same higher education institution as the researchers of the study. The questionnaires were administered online using LimeSurvey platform between May and June 2012. The construction and validation of the questionnaires were carried out by the Sakai community, involving 24 higher education institutions from several countries, in a project called Multi-Institutional Survey Initiative. Among the various aims of the questionnaires, we highlight the following within the scope of this study: assess the impact of the Sakai environment use on the support to the course units of the institution where the study was conducted.

When treating data regarding closed-ended questions, we followed the quantitative research paradigm, whereas the treatment of data regarding open-ended questions followed the qualitative research paradigm. Data was obtained from a sample of 347 undergraduates.

The sample was obtained from a population of 6943 undergraduates, thus corresponding to 5% of the population. Among the sample subjects, 63.7% are female and 37.3% are male. Their computer skills were classified into basic, intermediate and advanced skills. Among the sample subjects, 11.5% stated to have basic computer skills, 70.6% said to have intermediate skills, and 17.9% advanced skills.

The qualitative part of the study was carried through experimental procedures, as data was obtained through questionnaire and from the answers given by undergraduates to open-ended questions. In the analysis of the qualitative data, we followed a descriptive and interpretative approach by defining an analysis unit, identifying record units, defining categories and organizing the record units into those categories.

As far as the aims of the study are concerned, we can consider it exploratory. It is impossible to generalize the results as they were obtained from students of only one higher education institution. However, the results can be used as indicators to guide actions regarding the use of virtual learning environments in institutions other than the one where the study was conducted.

Results

Through the results obtained, we intend to contribute to the achievement of the aims defined for the research, namely, understand the assessment that students make of VLEs. As Palmer and Holt (2010) point out, understanding which elements of VLEs are used and valued by students represents a key element for effective decision-making regarding future investments in e-learning.

Hereafter we present the results according to the following topics: use frequency of VLEs; influence of undergraduates' computer skills on the access to VLEs; assessment of VLEs and of the digital tools which compose them by undergraduates.

Access Frequency to the Virtual Environment

The results associated with access frequency are presented according to their access, in the variables: every day (once or more), few times per week, once a week, few times per month, few times per semester, and never.

The assessment of access frequency to VLEs focused on students' perceptions regarding access to the VLE which they are connected to.

In Figure 1, we present the results regarding access to the institution's VLE.

The observation of Figure 1 enables the conclusion that the institution's VLE is used on a daily basis by a high percentage of students (59%). If we add up the percentages regarding the options "every day" and "few times per week", we notice that the vast majority of students access the VLE on a weekly basis (82%). Access frequency may imply the use of VLEs. In this sense, Lonn and Teasley (2009) did research on how the use of VLEs supports the traditional classroom, analyzing data obtained from students and teachers using VLEs. They concluded that almost all students (99%) access Internet at home and at the university campus, the average number of hours they spend on the Internet is over six hours per week in 83% of the cases but the number of hours spent on VLEs is much lower, as 81% only access VLEs five hours per week. The authors add that only 2% have used VLEs for more than five years, which suggests that most students who took part in the study started using VLEs at college. The same authors state that the main asset of VLEs as educational tools appears to be their capacity of making teaching more effective.

Influence of Computer Skills Level

Mainly over the last two decades, a huge effort has been made towards the creation, dissemination and use of digital technologies. Educational institutions have generally adhered to these technologies, and we witness different levels of knowledge regarding VLEs access, use and benefits. Having classified the computer skills of the students who took part in this study into basic, intermediate and advanced, we analyzed the influence of such skills on the variables under study. In Table 1, we present the relation between computer skills and the VLE access frequency.

In order to assess the influence of computer skills on the access to the institution's VLE, we

Figure 1. Access to the institution's VLE (n=347)

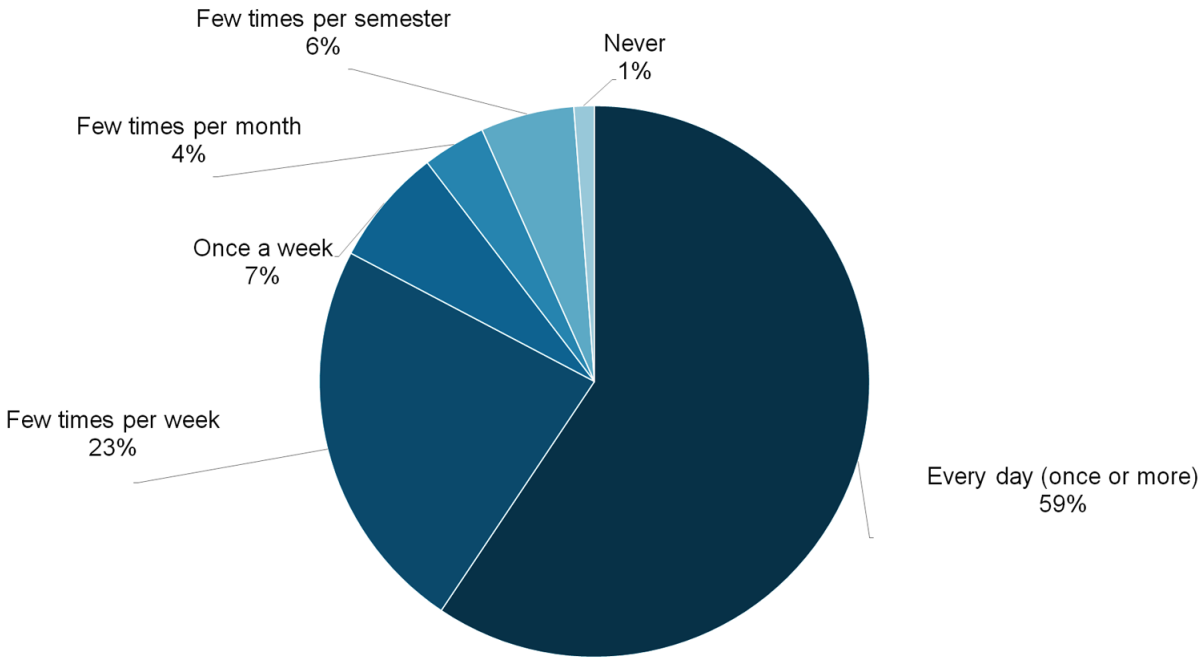


Table 1. Relation between students' computer skills and their access to the VLE

Computer Skills	Students' Access to the Institution's VLE						Total %
	Never %	Few Times per Semester %	Few Times per Month %	Once a Week %	Few Times per Week %	Every Day %	
Basic (n=40)	25.0	21.1	23.1	4.2	12.3	10.2	11.5
Intermediate (n=245)	25.0	63.2	69.2	75.0	69.1	72.3	70.6
Advanced (n=62)	50.0	15.8	7.7	20.8	18.5	17.5	17.9

considered the groups according to the skills stated: basic skills (BS), intermediate skills (IS) and advanced skills (AS). We determined the computer skills as the independent variable and the score obtained by each student in the assessed items as the dependent variable. We gave the items the following numeric scoring, respectively: Never (0), Few times per semester (1), Few times per month (2), Once a week (3), Few times per week (4), Every day (5). According to the established convention, the higher the score obtained, the higher the access frequency to the institution's VLE is.

In order to assess variance, we applied Levene's test of homogeneity of variances, considering the equality of variances between the groups (BS, IS, AS) as a null hypothesis. The results showed that it was possible to reject the null hypothesis at a significance level of 0.05, thus, no equality of variances was observed between the scores of the three groups. Due to the impossibility of admitting the equality of variances, we considered both Welch's test and Brown-Forsythe's test to be appropriate to compare the three groups' means. After applying each of these tests, we concluded that it was not possible to reject the null hypothesis of equality between the three groups' means, at a significance level under 0.05. Therefore, it is impossible to conclude that there are significant differences in the VLE access according to students' computer skills.

The adequate application of the referred statistical tests allows the conclusion that we can admit that there are no significant differences between the score means obtained by the groups of students. In other words, no evidence was found that students' computer skills influence access frequency to the institution's VLE.

Value Given to Digital Tools

The use of VLEs as well of the digital tools which compose them depends on the response they can give to potential users, as well as on the value that these users assign to them, namely regarding the response to educational goals which enable interaction between teachers and students. As Albirini (2006) points out, when universities promote the use of ICT, they need to understand teachers and students' attitudes towards their use.

Therefore, in this study, we assess the value that undergraduates assign to their institution's VLE regarding interaction, submission of assignments and access to contents, and as support tools to course units.

Interaction

Interaction among students as well as between them and the teachers must be permanently enhanced and planned so as to build one of the effective ways to promote collaborative learn-

ing, facilitated by VLEs potentialities and by the connections that current technology enables to establish.

Barberà (2004) suggests that virtual interaction not only enhances students' learning but also represents a component of the nature of the virtual context itself, thus promoting its vitality.

In Table 2, we present the distribution, in percentage, of the scores obtained regarding the value that undergraduates assign to VLEs for the development of interaction with teachers.

By observing Table 2, it is possible to say that the most valued aspects as far as interaction with teachers is concerned are: checking exam results; receiving messages or notices; checking the teacher's office attendance hours; and checking the schedule of activities.

The importance given by students to the information they receive from teachers and to accessing assessment results corresponds to the aspects teachers value in virtual environments, as shown in a study conducted by Pedro and Cabral (2013). In this study involving a sample of 342 university teachers from various scientific fields, the researchers assessed the purposes of using virtual learning environments regarding aspects of resources and information availability, communication, assessment and cooperation. They concluded that the most valued aspects were those regarding resources and information availability and assessment.

With regard to the importance given to the environment for fulfilling tasks or for obtaining useful information, we assessed, among others: check the schedule of activities, receive messages or notices, do online tests, check exams results, use the plan of activities, check the teacher's office attendance hours, participate in groups, and monitor progress.

Submission of Assignments and Access to Contents

Submitting assignments and accessing contents are current attitudes of the modern world. When submitting their assignments, students are taking responsibility for their creation and authorship. This may motivate them and increase their willingness to always do better, as after becoming public, an idea or a work can be evaluated, which also implies the evaluation of the person who created it, for the better or for the worse. Gray (2010) claims that the educational community is interested in enabling students to demonstrate their learning achievements by creating contents in these new platforms, namely to develop their skills, increase their sense of criticism and review among peers as well as their sense of creativity.

The submission of works and access to contents are potentialities whose value given by students is presented in Table 3.

Table 2. Value assigned by students to the use of the VLEs for the interaction with teachers (n=347)

For the Interaction with Teachers, the VLE Is Valuable to ...	Not Used %	Disagree %	Neutral %	Agree %
Check the schedule of activities	6	5	13	76
Receive messages or notices	1	1	3	94
Do online tests	29	10	23	37
Check exam results	1	1	3	95
Use the plan of activities	12	5	15	68
Check the teacher's office attendance hours	7	4	12	77
Participate in groups	20	6	21	54
Monitor my progress	17	9	23	52

Table 3. Value assigned by students to the VLE for the submission of assignments and access to contents

For the Submission of Assignments and Access to Contents, the VLE Is Valuable to ...	Students (n=347)			
	NU %	D %	N %	A %
Submit assignments	9	3	11	78
Submit part of my assignments	14	8	19	60
Share parts of the assignments with colleagues	18	9	20	53
Cooperate with colleagues in the fulfillment of tasks	18	8	21	53
Read or comment on colleagues' assignments	20	12	24	44
Ask questions before the lesson	16	11	20	53
Ask questions during the lesson	21	21	23	35
Ask or answer questions after the lesson	12	7	17	64
Share contents with colleagues	18	9	20	54
Access bibliographic resources	10	5	13	72
Provide feedback on the course unit	15	7	20	58

Caption: NU – Not used; D – Disagree; N- Neutral; A – Agree.

Regarding the submission of works or access to contents, the three aspects most valued by the highest percentage of students were: submitting works and accessing bibliographic resources, and asking or answering questions after the lesson. Similar results were obtained in previous studies (Palmer and Holt, 2012; Mahdizadeh, Biemans and Mulder, 2008).

The potentialities valued by the highest percentage of students were: submit assignments (78%), access bibliographic resources (72%) and ask questions after the lesson (64%).

Among the various aspects assessed by students regarding the importance of VLEs, we highlight: submit assignments, cooperate with colleagues in the fulfilment of tasks, ask questions after the lesson, share contents with colleagues, access bibliographic resources, and provide feedback on the course unit.

Among these, we highlight the importance given by students to the possibility of submitting assignments on the VLE as well as of sharing contents with colleagues.

Support Tools to Course Units

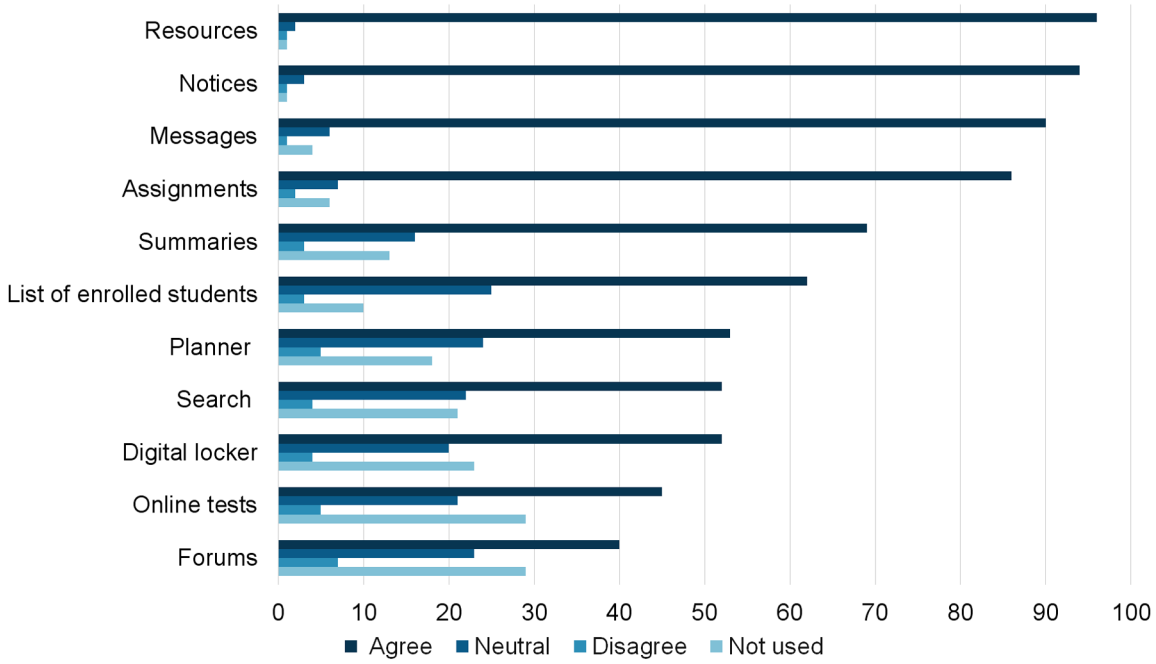
The use of digital tools requires knowledge of their features and educational potentialities, as well as the adoption of teaching and learning strategies which enable their use within the educational context.

Starobinas (2012) suggests that in order to achieve the dissemination of a culture of using educational resources, it is necessary to include students into the process of creating regular activities associated with the syllabus and to stimulate individual initiatives of producing contents in complementary activities.

In this study, we also assessed the value of the digital tools which compose the institution's virtual environment in the support to course units. In Figure 2, we present students' assessment of those tools.

The data presented in Figure 2 shows that the VLE tools most valued by the highest percentage of students are: resources, notices, messages and assignments, thus confirming the results obtained

Figure 2. Students' assessment of digital tools as a support to the course units (n=347)



in previous studies (Carvalho, Areal and Silva, 2011; Palmer and Holt, 2010).

The tasks associated with VLEs valued by the highest percentage of students were: check exams results (95%), receive messages or notices (94%), check the teacher's office attendance hours (77%), and check the schedule of activities (76%).

This shows that great importance is given by students to VLEs potentialities with regard to resources availability and to the possibility of receiving notices from teachers. However, the fact that tools are highly valued does not necessarily imply their use. In a research work related to the extension and nature of the use of digital technologies for undergraduates' learning and socialization, Margaryan, Littlejohn and Vojt (2011) state that students use a limited range of technologies, and the use of collaborative tools for creating knowledge, virtual worlds and social networks websites is rather low.

Impact of the VLE on the Support to Course Units

The assessment of the impact of the VLE on the support to course units followed a qualitative approach. Within qualitative research, the researcher can be considered as a crucial tool in the data collection. However, we must clarify that, although researchers can start from several interpretations, they must assume that after defining the concepts involved and the adequate procedures which guide the research, the data and the conclusions obtained must be easily understood and accepted, with internal consistence and without contradictions. Therefore, we will try to clarify some concepts associated with qualitative research, particularly with content analysis, namely the concepts of analysis unit, record unit and category.

Content analysis represents a research methodology used to describe and interpret the content

of all types of documents and texts, leading to systematic, qualitative or quantitative descriptions, thus helping to interpret information and understand meanings in a deep level (Moraes, 1999).

When we are in possession of an amount of information, it is important to take real advantage of it, giving it sense by organizing it in a way that enables the identification of each of its parts and its further grouping so as to distinguish the most representative information regarding the topic under study from the least representative. The whole of the information under analysis can be a text, a book, a set of answers to a question or a group of answers to a questionnaire, among others. Therefore, the following question arises: how can we measure this magnitude (amount of information)? Normally, we measure a magnitude by selecting a unit and then checking the number of times that the unit fits within the magnitude, considering that number of times to be the measure of the magnitude.

According to Moraes (1999), the process of content analysis requires the following stages: preparing the information, turning the content into units, categorizing or classifying the units into categories, describing and interpreting the data.

Within the context of content analysis, and considering an amount of information for analysis, we consider the analysis unit as the minimal unit which enables the division of all the information into several units. Each of these units is identified from a minimal unit and designated as record unit. Record units are organized according to criteria which must be clearly defined into categories. Thus, each category represents a class composed of a set of record units possessing a similar meaning or satisfying the same association criteria.

According to Bardin (2008), the analysis unit is the significance unit to be codified and corresponds to the segment of content to be considered as the base unit, intending the categorization, the counting and the frequency. In other words, we can consider as analysis unit the minimal unit of information which enables to codify the information under analysis within a set of other units, each of which will be called record unit. The same author adds that the categorization is an operation of classification of elements included in a set through differentiation and through regrouping according to previously defined criteria. The categories are classes which integrate the record units. These elements are grouped due to the fact that they share certain characteristics in an attempt to present the meaning of the raw data in a condensed and simplified way.

Categorization is a procedure to group data considering what there is in common between its parts. Classification takes place by similarity or analogy, according to criteria established or defined previously in the process (Moraes, 1999).

After organizing a set of information within a set of categories, the latter must verify at least two essential characteristics: exclusivity and completeness. Exclusivity ensures that there is no record unit belonging to more than one category; completeness ensures that each record unit identified within the set of information was integrated in some category.

Content analysis is essential when researchers follow the qualitative research paradigm. Qualitative research is quite complex at times due to the various dimensions it involves as well as the difficulty in defining the analysis unit and in codifying the record units in coherence with the analysis unit.

The potentialities of VLEs are numerous. However, it is essential that such potentialities are known to their potential users, namely teachers and students. It is important to know the features and potentialities of learning environments, but not less important is to identify the impact that undergraduates think they have.

The results regarding the impact of virtual learning environments on the support to course units were obtained from the answers given by a sample of undergraduates about the Sakai environment used in their institution.

The data was obtained from the answer to the question: What do you think about the impact of using the Sakai environment on the support to course units?

After reading all the answers and after assessing which analysis unit best translated the subjects' answers so as to enable their categorization, we defined as analysis unit: "each opinion identified in the answers given by the subjects who participated in the study". The use of this analysis unit enabled the identification and codification of all the opinions given in the answers, each of which was identified as a record unit.

Not all the sample students answered the question. Thus, among the 347 students, 191 (55%) answered the question, and on the whole of the 191 answers, we identified 403 record units.

Bearing in mind that the aim of the question presented was to assess the impact of using the Saki environment on the support to course units, we defined on the whole of all the records units the following categories: general positive impact, specific positive impact, general negative impact, specific negative impact, neutral impact, and others. We defined each category as follows:

- **General Positive Impact:** When the opinion is favorable to the features or use of the Sakai environment, without focusing any specific aspect;
- **Specific Positive Impact:** When the opinion is favorable to the features or use of the Sakai environment, focusing some specific aspect;
- **General Negative Impact:** When the opinion is unfavorable to the features or use of the Sakai environment, without focusing any specific aspect;
- **Specific Negative Impact:** When the opinion is unfavorable to the features or use of the Sakai environment, focusing some specific aspect;
- **Neutral Impact:** When the opinion refers to the Sakai environment, but does not transmit any position, either favorable or unfavorable;
- **Others:** All the opinions which are not included within the previous categories, as they are not related to the Sakai environment.

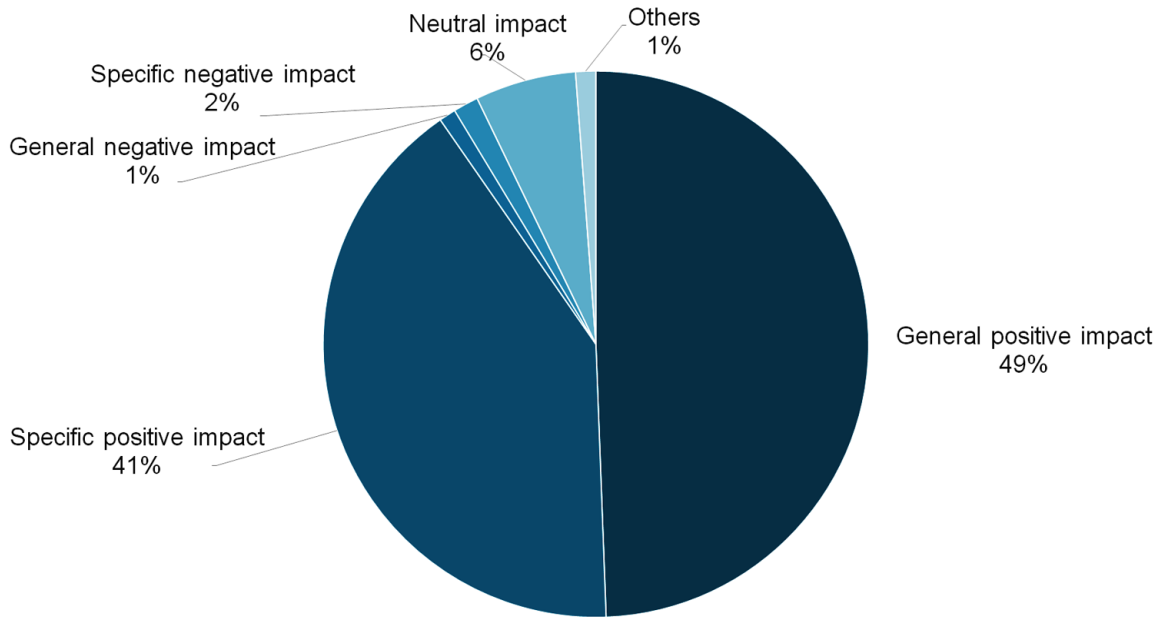
Hereafter we present the results according to the analysis unit and the categories defined. Figure 3 shows the distribution of the record units into the respective categories.

The data presented in Figure 3 shows that the most representative categories are the general positive impact and the specific positive impact, which confirms the acknowledgement of the positive impact regarding both the general context of course units and specific aspects associated with course units.

We present some examples of record units integrated in the respective categories, from the students' opinions regarding the impact of the Sakai environment on course units:

- **General Positive Impact:** It was quite good; I think it is an asset; It is very good to have the Sakai environment; I consider it an essential tool for any student; It is extremely important; Very good; It is highly valuable.
- **Specific Positive Impact:** It enables communication between teachers and students; It is a complement which establishes the connection between the student and the teacher; The Sakai environment enables permanent access to resources; The comfort of checking exam results without having to go to the school; It is a support for sharing information with teachers.
- General Negative Impact: **The impact is low.**
- **Specific Negative Impact:** It should have a chat so that we could talk to a teacher for example without anyone seeing the conversation.

Figure 3. Impact of the Sakai environment on course units (n=403)



- **Neutral impact:** With no opinion; Nothing to say.
- **Others:** It occurs with 2 Health course units.

Summing up, as far as general positive impact is concerned, students consider that the Sakai environment is an essential tool for any student and essential in the support to course units. The specific aspects which benefit from that impact are the enhancement of communication between teachers and students, the permanent access to resources and credible information regarding course units and the closer contact between students and teachers.

As far as general negative impact is concerned we highlight "the impact is low" as the most representative of students' opinion. Specific negative impact was expressed by a low number of opinions, among which we highlight the need to introduce other tools into the Sakai environment. Neutral impact was identified in a reduced number of opinions, among which "no opinion" or "no comment".

Thus, we assessed the impact of VLEs on the support to course units based on the answers that the sample subjects gave to the open-ended questions presented in the questionnaire, defining each opinion identified in the subjects' answers as the analysis unit, identifying the record units, defining categories, and integrating them within the respective categories.

Among the answers given by the 347 sample subjects, we identified 403 record units, which were inserted within the categories: general positive impact, specific positive impact, general negative impact, specific negative impact, neutral impact, and others.

The categories with the highest representativeness, due to the quantity of opinions they integrate, were general positive impact (49.6%) and specific positive impact (41.1%) of the virtual learning environment on the support to course units. Therefore, the results show that students find VLEs to have a positive impact, especially aspects related to their usefulness, enhancement of the communication between teachers and students, and access to credible information.

In a nutshell, higher education students acknowledge a very positive impact of the VLE used in their institution, both by valuing the VLE as a whole and by valuing specific aspects associated with its use.

FUTURE WORKS

The search for ways to make virtual learning environments more profitable within the context of higher education continues to represent a challenge for researchers, teachers, students and institutions. Higher education should be responsible for innovating and promoting the use of ICT and associated digital resources within the teaching and learning process, thus preparing individuals to intervene in society in creative, innovative, competent and grounded ways.

The results presented show that undergraduates do have a frequent connection to virtual learning environments, use them regardless of their computer skills and value their potentialities and the impact they may have on the teaching and learning process.

Also, we highlight that the importance of this research work lies essentially in the knowledge it provides to the scientific community interested in implementing virtual learning environments in higher education so that they can assess the importance of the resources they intend to use. This research work provides indicators which must be taken into account for future studies regarding access, value and use of virtual learning environments and the digital tools which compose them within the context of higher education, as well as regarding the impact that the use of these environments has on the support to the course units which compose the curriculum of the degrees students attend.

Therefore, further research within this area is justified, so as to better integrate new resources and improve existing virtual learning environments. As a starting point for the integration of new resources, there must be a combination of the educational digital resources newly built and assessed with the new pedagogies as well as with the informal, non-formal and formal contexts in which learning takes place and must be promoted.

CONCLUSION

Virtual learning environments are present within teaching and learning contexts in all levels of education, particularly in higher education, where they are part of the daily life of institutions, namely of teachers and students.

The results presented in this chapter are supported by data obtained through questionnaire, in a study involving 347 undergraduates. The study focused on students' perceptions regarding access frequency to virtual learning environments, the value of virtual learning environments and of the digital tools which compose them, and the impact of VLEs on the support to course units. We hereafter present the main conclusions drawn from the study.

Students' computer skills were classified by themselves as basic skills, intermediate skills and advanced skills. The percentage of students accessing the virtual learning environment on a daily basis is higher among subjects with intermediate computer skills than among those with basic or advanced skills.

As far as interaction is concerned, the aspects valued by the highest percentage of students were: check exam results, receive messages or notices, check the teacher's office attendance hours and check the schedule of activities.

With regard to the submission of assignments and access to contents, the aspects valued by the highest percentage of students were: submit assignments, access bibliographic resources and ask or answer questions after the lesson.

The virtual learning environment tools valued by the highest percentage of students, over 90%, were: resources (supporting the course unit), notices, messages and assignments.

The part of the study regarding the assessment of the virtual learning environment impact on the support to course units followed a qualitative approach. In the analysis of answers, we considered "each opinion identified in the answers given by the subjects who participated in the study" as the analysis unit. Considering the defined analysis unit, 403 record units were identified and inserted into the categories: general positive impact, specific positive impact, general negative impact, specific negative impact, neutral impact, and others.

After inserting the record units into the respective categories, the most representative categories of students' opinions were found to be general positive impact and specific positive impact, which shows that students consider that the virtual learning environment adopted by their institution (Sakai environment) is an asset and has a very positive impact on the support to course units.

Considering the general positive impact expressed by students, we highlight that they consider the institution's Sakai environment as an essential tool for any student and crucial in the support to course units. The particular aspects which benefit from this impact are the enhancement of communication between teachers and students, the proximity between teachers and students and the permanent access to credible resources and information related to course units.

With regard to the negative impact and the neutral impact, the results show that students find them quite irrelevant.

The conclusions drawn from the study are that the majority of students: access the VLE every day; value the VLE potentialities which enable to submit assignments, access bibliographic resources and ask questions after lessons; use the VLE to check exam results, receive messages or notices, check the teacher's office attendance hours and check the schedule of activities; consider the VLE to have great general positive impact and specific positive impact, namely regarding the enhancement of access to materials and of the communication and interaction process among students.

The results indicate a good acceptance of the VLE by the students who use it.

We consider that VLEs represent the main meeting and interaction space between students and the institution.

The conclusions drawn from this study cannot be generalized to the Portuguese public higher education context because all the subjects who took part in the study belong to the same institution. However, they represent indicators which must be taken into account for future works regarding the access, value and use of virtual learning environments and the digital tools which compose them.

It is important to continue to invest in the use and familiarity with virtual learning environments, as students have shown to use them frequently, value them highly and assign them a quite positive impact on the support to the course units that they attend.

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KEY TERMS AND DEFINITIONS

Analysis Unit: The minimal unit which enables the breakdown of the whole data into several units.

Category: A class composed of a set of record units which have an identical meaning or sense or which meet the same association criteria.

Computer Skills: The level of knowledge regarding the use of IT systems that a common user has.

Course Unit: The academic unit with individual specific training goals which requires the student's registration and consequent assessment translated into a final mark.

Digital Educational Resources: Digital entities produced specifically with the purpose of supporting teaching and learning.

Interaction: Actions developed between the main stakeholders within a virtual learning environment.

Record Unit: The identification of each one of the minimal units identified within the set of data.

Sakai Environment: A flexible environment of teaching and learning as well as of academic cooperation, developed by a community involving several universities with the main aim of responding to and meeting the needs of students, teachers, researchers and organizations.

Virtual Learning Environment: Virtual space integrating a set of digital resources and tools which favor the interaction among students, teachers and contents which potentialities for the implementation of learning pedagogical strategies.

Chapter 19
Like It:
A Facebook E-Learning Architecture for Higher Education

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ABSTRACT

Social networking environments have become a ubiquitous part of the university experience. Accordingly, postsecondary institutions have started to consider the role that social networking can play in teaching and learning across academic disciplines. This case study documents findings from a 2012-2013 mixed-methods data collection in six graduate and undergraduate Digital Literacies and New Media Literacies courses at a major Canadian comprehensive university. It examines the pedagogical implications of adapting the Facebook platform for online collaboration and multimedia learning in blended courses, and offers a model of Facebook implementation for engineering and architecture education. Questions guiding the research ask: What is gained pedagogically through the use of Facebook in higher education courses? What are the pedagogical challenges encountered, and how might these be addressed? Suggestions based on observed trends are offered for the effective inclusion of Facebook as a beneficial pedagogical component in the design of e-learning platforms for higher education.

INTRODUCTION

For postsecondary students across disciplines and fields, online social networking environments have become a ubiquitous part of social experience (Johnson, Adams Becker, Estrada, & Freeman, 2014). Accordingly, postsecondary institutions have begun to consider the role that social networking can play in the pedagogical process. With an awareness of how students are using social media to find resources, co-create knowledge (Bowers-Campbell, 2008), and crowd-source for public

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interests, educators can leverage social media use to improve the learning process (Buckingham, 2008; Lankshear & Knobel, 2008). This bridge leads to changes not only in practice, but more importantly, in the way we think and design for teaching and learning in the digital age (Schmidt & Cohen, 2014). It further invites an emphasis on "knowing in action" (Schon, 1987): combining theory with practices that are particularly important to built environment applications found in both engineering and architecture education (Bala & Arat, 2013).

This case study (Creswell, 2014; Yin, 2009), which forms part of a longer-term study of Facebook usage in higher education, documents and analyzes classroom-based data from a mixed methods study spanning a single academic year (2012-2013) and a total of six graduate and undergraduate New Media Literacies courses at a major Canadian comprehensive university. It examines the pedagogical implications of adapting the Facebook platform for online collaboration and multimedia learning in blended (face-to-face and online) courses, and provides valuable insight into a working model for social media learning frameworks across disciplines and fields in higher education.

Three central questions guide our research: What is gained pedagogically through the use of Facebook in higher education graduate and undergraduate courses? What are the challenges encountered? And how might these issues be addressed? The objective of the case study is to document pedagogical possibilities for Facebook use in blended learning settings across academic disciplines, where the e-learning platform is transferrable and adaptable for content specific tasks. The authors of this chapter have been engaged since 2007 in experimental and exploratory research of Facebook as a learning medium in university classrooms. Since then, although academic interest – and with it a wave of relevant literature – has grown in this novel research area, there is still much to be gained pedagogically through studying the use of social media in higher education. This research is especially needed in engineering and architecture education where, to date, there are few studies investigating pedagogical possibilities in regard to employing Facebook or other social media (Bala & Arat, 2013). This chapter illuminates our approach and findings regarding Facebook as a critical component of an e-learning blended course design.

BACKGROUND

Social media challenge the existing structures of universities by breaking down strict hierarchical pedagogical structures and allowing learners to engage in meaningful and critical conversations in online learning environments (Morbey, Sabeti, & Frank, 2014). Further, social media provide students with opportunities for more diverse and enriching conversations with educators; learners become team players, technologically collaborating in the production of knowledge, sharing their personal insights, and engaging in debates. These activities are particularly relevant to engineering and architecture education where students and professionals come together to complete designs of built environments (Bala & Arat, 2013). Whether pertaining to the study of architecture, engineering, or education itself, technology enhanced learning platforms are becoming more common at the postsecondary level, but have yet to be fully understood.

Learning, based on the notion of participatory culture (Jenkins, Clinton, Purushotma, Robison, & Weigel, 2009), can be facilitated by social media learning. What Gee (2004) calls affinity spaces are in fact participatory cultures – instructionally designed spaces with low barriers for engagement that offer strong support for creating and sharing one's creations, informal mentorship, and potential full involvement. Such spaces facilitate rich pedagogical possibilities in and across technology enhanced, synchronous and asynchronous, collab-

orative learning environments (Gibb & Walker, 2013; Jenkins et al., 2009) that focus on shifting learning from an individual activity to one involving a community, and on developing new media literacies – a set of cultural competencies and social skills – necessary for participation in a new media world (Jenkins et al., 2009). These competencies, also essential in an interconnected, evolving global landscape, include collaboration, creativity, critical thinking, and communication (Lankshear & Knobel, 2006; Trilling & Fadel, 2012; Vockley, 2008), all of which are important to education and to the workplace. Further, these competencies guide a transition to a learning environment that is student-directed and engages team building, collaboration and flexibility, empowers students as generators of learning content and contexts, and bridges the formal learning environments of engineering and architecture studios with informal learning environments to bring forward "situated authentic practice" (Cochrane & Rhodes, 2013, p. 372). This changing work environment, where crowd-sourcing informing design principles have become ubiquitous along with the engagement of technologies in the workplace, has been an increasing desire of administrators in higher education.

There is, however, tension in the literature regarding the use of social media (and specifically Facebook) for teaching and learning. Some studies report that students, faculty, and staff are hesitant to use social media for academic purposes (Charnigo & Barnett-Ellis, 2007; Madge, Meek, Wellens, & Hooley, 2009) and that the practice is not widely accepted in the academic realm despite consistent use among college students (Bowers-Campbell, 2008), who continue to view social media as a social environment, and thus somewhat problematic as a learning environment (Morbey et al., 2014). Nevertheless, others report that university students are strongly open to the possibility of using Facebook and other social media to engage course work (Morbey et al., 2014; Roblyer, McDaniel, Webb, Herman, & Witty, 2010). As research continues to demonstrate that key technologies and forms of media are able to improve interactions between content and users, multimedia educational solutions will continue to impact academic, governmental, and corporate interests (Park, 2013).

Our present case study examines the pedagogical implications of adapting social media, specifically Facebook, for online collaboration and multimedia learning in blended environments. Blended learning refers to the integration of face-to-face and online approaches to education (Bleed, 2001; Garrison & Kanuka, 2004; Graham, 2006; Vaughan, Cleveland-Innes, & Garrison, 2013). Heiberger and Harper (2008) assert that Facebook is the "ultimate synthesis of student-relevant data" (p. 20), in that it is a platform for student creativity and the artistic presentation and representation of the self through the photos, videos, multimedia, collaboration and dialogue that users contribute to the network. Its use as a blended learning medium in higher education also assists technologically enhanced collaboration and builds upon recent research (Cavanagh, 2012; Cochrane & Rhodes, 2013; Dziuban, Hartman, Juge, Moskal, & Sorg, 2006; Park, Johnson, Vath, Kubitskey, & Fishman, 2013) indicating how:

- Institutions see blended learning as a model that makes efficient use of physical and virtual space;
- Pedagogy can bridge in-class formal learning with informal learning environments engaging situated practice;
- Faculty benefit from increased flexibility in teaching schedules; and
- Students appear to be more satisfied and achieve at a higher level than either fully face-to-face or fully online classes.

In a study of students' use of Facebook, it is noted that more than 90 percent of US college students use this form of social media (Ellison, Steinfield, & Lampe, 2007; Pempek, Yermolayeva, & Calvert, 2009). Another study notes that

students spend more time on Facebook than on university portals and e-mail accounts (Roblyer et al., 2010). As Facebook has both synchronous and asynchronous functions, it offers many of the same advantages as institutionally mandated learning management systems; it allows flexible "anytime, anywhere" access and keeps a visual and textual record of communications, with user-defined privacy settings.

FRAMING THEORY

To theoretically frame the case study, we call on the ideas of contemporary media specialists, as well as Actor Network Theory (ANT). Jenkins et al.'s (2009) theory of participatory culture describes offline and online groups that embody an architecture of participation. A participatory culture is a culture with relatively low barriers for artistic expression, strong support for creating and disseminating one's creations with others, informal mentorship (whereby the more experienced scaffold the learning of novices), and members who feel socially connected with one another, value others' opinions, and believe both that their contributions have value and that they are free to contribute, but not forced to do so (Jenkins et al., 2009). Contributions take various forms, including affiliations, expressions, collaborative problem solving, and circulation (Jenkins et al., 2009). The collaborative, peer-to-peer, collective, and global nature of the Facebook platform supports the emergence and cultivation of participatory cultures. Facebook users are active agents who construct their social realities while engaging in communal discourse. Thus, as active participants, students can leverage Facebook for academic purposes by becoming consumers and producers of educational content.

Jenkins, Ford and Green's (2013) notion of "spreadable media" maps fundamental changes taking place in the contemporary global media environment, where many are involved in the creation and circulation of content that is disseminated through both formal and informal networks: this notion captures the movement of content via social media and, with its focus on the global, embraces the nature of audience engagement. With transnational flows at the heart of spreadable media, an examination of social media learning in higher education will benefit from this frame, in turn furthering the sharing of knowledge creation and dissemination.

More recently, we have seen the emergence of metamedia platforms in 3-D educative online environments (Morbey, 2011; Young, 2010), and the use of 4D space in interactive architectural design (Bullivant, 2005). These virtual interactive environments provide users with a dynamic, immersive experience and enable them to create, construct, embed, unify, and archive text, video, and 3-D and 4-D artifacts along cloud-based on-demand computing systems (Lombardi & Lombardi, 2010). This metamedia engagement has a strong affinity with researchers, and educators, who have studied Web 2.0 usage, participatory culture, and remix culture (Gee, 2007; Jenkins et al., 2009; Lankshear & Knobel, 2003; Lessig, 2008). Facebook enhances these possibilities and works as an agent of change across higher education pedagogy.

In his framework of affinity spaces, Gee (2004) echoes the preceding thinkers in conceptualizing a shared space constructed around common goals and interests, where content is generated, consumed, and transformed by a variety of participants. The content, form, and roles within the affinity space are all continuously negotiated through participant interactions and shared leadership, and ultimately become cultures of participation (Jenkins et al., 2009). This lens is expanded by including Actor Network Theory (ANT), developed and articulated in the field of Science and Technology Studies by Latour (1987, 2005), Law (2004), and Callon (1987). ANT reads the social – institutions, practices, and interactions – as the product of engagement

between human and non-human actors. Latour (2005) stresses that agency is distributed across actors that co-constitute a network. Human action is shaped and made possible by non-human agents, which have been designed to enable certain forms of activity. An ANT approach fits a study of social media technologies because the technology works as an agent, or actor, in collaborative knowledge building and sharing (Papert, 1980). ANT illuminates the interconnections between technologies and contexts in the development of affinity spaces for e-learning environments across university fields and disciplines.

CASE DESCRIPTION: LEARNING WITH FACEBOOK IN HIGHER EDUCATION

Methods and Modes of Inquiry

Given the extant literature and theoretical framing discussed above, the authors decided to employ Facebook as the online learning medium for our course offerings. Having extensively used other academic-only learning management systems in the past, our experience was well aligned with findings in the research literature: students were not engaging positively with these learning systems, and found their use complicated and disjointed. Accordingly, we considered leveraging the popularity and growing prevalence of Facebook as a learning medium. At the time of earlier iterations of the courses, Facebook was only beginning to gain notoriety amongst postsecondary students, and was viewed exclusively as a social (and not a learning) medium. However, we viewed this as an opportunity to meet our students where they were most comfortable experientially, as well as most likely to engage in intellectually fruitful discourse.

For the three undergraduate-level New Media Literacies courses and the three graduate-level Digital Literacies and Social Media courses taught in the 2012-2013 academic year and addressed in this case study, the instructor developed a blended learning model, combining face-to-face and online modes in order to enrich the course content and create an immersive social media experience for student collaboration (Garrison & Kanuka, 2004; Gee, 2013; Glazer, 2012; Owston, York, & Murtha, 2013; Snart, 2010; Vaughan et al., 2013). Facebook was selected for its popularity and the prevalence of its use amongst university students – they were already comfortable working in this online space – and because the instructor believed it could engage students with the course foci by inviting them to create content and situate it in informal practice in ways that may be relevant to, for example, engineering and architecture education.

At the first meeting of each course, the instructor and teaching assistant (TA) introduced Facebook as a medium for facilitating the course objectives, and as the locus for this experimental research, and invited the students to join the project. The TA built the course's main Facebook page and invited the students to join. Small Facebook groups were also built, each accommodating 10 students, for discussion, creation, and production of course work. Each student was required to join both the main Facebook group and one of the small groups; the intention was for them to engage in meaningful academic – formal and informal – discourse and creation through their contributions to these dynamic multimodal shared group pages. The Facebook-based interactions were designed to complement the in-class component of the course, and to facilitate informal learning in situated practice (Cochrane & Rhodes, 2013). The students were instructed in Facebook privacy settings as well as possible alternative names to their regular Facebook name. Each Facebook page was closed and "private" for the protection of the students. Once the course was completed, the Facebook pages remained available to students as a resource for further work.

Students were required to post to their Facebook group at least twice a week for the duration of the course: once in response to the week's assigned readings and videos, and again in response to a classmate's post. With the aim of expanding pedagogical possibilities and facilitating cognitive shifts, students were encouraged to keep their textual postings terse and focused, and to consider other possibilities for their postings, including multimedia files such as photos, other images, and videos. In terms of the face-to-face component, the courses followed a seminar format, where students delivered presentations in small groups. Each week, those conducting the in-class presentation also served as online facilitators by posting generative questions before their presentation.

Initially, the Facebook groups were moderated by the course instructor as well as the course TA. The TA's role was largely technical – to guide students who were unfamiliar with Facebook to create accounts, adjust privacy settings, and understand the basics of navigating the relatively intuitive interface – while the instructor's involvement in discussions was intentionally limited to allow group members the opportunity to develop collaboration organically, without external influence or pressures. In the event, as students began to fulfill textual and multimedia requirements, the group pages almost immediately began to flourish with student-generated content (Morbey et al., 2014), at which point the roles of both moderators became even less visible. Students were using the shared, online group space for the purposes originally intended, but also for other course-related purposes that the instructor had not initially conceived. For example, seminar groups would build their own page and use various Facebook components to develop their collaborative course seminar presentations.

Given the course content, students were also encouraged to use their Facebook groups as a "testing ground" for expanding their knowledge of social media and generative media outside of Facebook. Accordingly, this case study research could serve to complement engineering and architecture courses through exposure to the experience of diverse media, particularly for built environments, in ways that would support their learning as well as co-creation and co-production. Social media, content generation, and pedagogical platforms were discussed, in class, both in relation and in contrast to Facebook. Similarly, with students' consent to examine their use of Facebook in this setting, which was constructed from the outset as both a course and a locus for experimental research, class discussions addressed the efficacy of Facebook and other social media. At the completion of each course, all students participated in a survey questionnaire, with both quantitative and qualitative components, to explore pedagogically their Facebook experience (Creswell, 2007; Glesne, 2011). To protect the students, informed consent ethics forms were filled out by each student.

Data Sources

A survey was created to elicit anonymous feedback from students about their experience of using Facebook as an educational online medium in postsecondary environments. The survey was a combination of Likert-scale and short response questions, and was administered through a choice of paper-and-pencil or web-based means. To ensure the clarity of the survey items, two preliminary drafts of the survey were reviewed with a group of undergraduate students for clarity in language and expectations for completing the survey correctly.

A consideration of any data collection process must recognize that methods of evaluation are not equal in their validity and reliability. When employing a 5-point Likert scale, researchers need to be aware that a mid-point response is both a methodological and epistemological concern (Tsang, 2012). In terms of methodology, an instrument of study is said to be reliable if and when it produces consistent results: if, for instance, assuming no intervention, the data collection brings forward

the same set of information each time the instrument is used. An instrument is said to be valid if the results it produces are accurate: for example, data should be consistent. These two traits are inextricably linked as unreliable instruments cannot produce valid results. A 5-point Likert scale is unique due to the presence of a mid-point response option, but it has been shown that the presence of a mid-point can in fact produce higher statistical reliability within a study (Adelson & McCoach, 2010). Epistemologically, the dilemma again concerns the mid-point. In one way, the presence of a neutral score ("neither agree nor disagree," "undecided," "don't know") can allow for a more true expression of truth on behalf of the respondent, but the main concern is that the researcher is able to distinguish clear meaning-making with the response (Raaijimakers, Hoof, Hart, Verbogt, & Woolebergh, 2000). For this reason, the mid-point response in this survey was labelled as "on the fence," to signify a response currently in limbo, and neutral in its position between positive and negative. The choice of a 5-point Likert scale survey for this case study, administered mainly online, fit with the empirical environment: it was a conscious decision by the researchers to create a methodologically sound survey instrument with an unambiguous epistemological connotation.

While the blended learning Facebook model has been used by the course instructor since 2007, the collection of survey data (using convenience sampling) has taken place during two phases during this period. The first phase occurred during the 2007-2008 academic year, with the participation of two undergraduate courses (n = 51). Following that first phase of data collection, the survey tool was reviewed by the authors together with a group of participating students to ensure that the questions asked were accurate representations of the intellectual intentions of the authors. That initial review led to only minor adjustments to the language of the survey, and from that point it has remained unchanged. The second and more refined phase began in early 2012 and continues in the current iterations of both courses.

In the time between the two phases of data collection, Facebook use in the courses has evolved pedagogically through the input of students. More recent data collection is currently being completed by the research group, and will be presented in a future publication, as the landscape of social media resources as well as student engagement has changed drastically over the past seven years. At the time of writing, however, this second phase – the focus of this chapter – has included the participation of students (n = 139) from three undergraduate and three graduate courses (as detailed above). Although our sample in this one-year case study is small, the research offers "Observed Trends" that give insights into Facebook e-learning as potentially helpful across university fields and disciplines, and particularly for engineering and architecture education.

While the results of the survey tool constitute the foundations of the analysis presented in this chapter, it is worth noting that given the nature of the courses in which the participating students were enrolled, there were opportunities throughout the course to collect additional qualitative data. At various points the authors engaged in, and were informed by, ongoing discussions with students – in both large and small groups – about their experiences with Facebook in the postsecondary learning environment. Often, these discussions served as a catalyst for ensuing Facebook discussions online; some led to changes in students' Facebook usage. In a similar vein, where schedules and survey completion permitted, the authors were able to present the findings of the survey to the students in the course, in an effort to delve deeper into the understanding of students' perspectives and beliefs. This additional step was possible in both phases of data collection, and proved to be valuable to both the course instructor and the students.

Data Analysis Procedures

The survey instrument completed by students enrolled in the courses recorded anonymous feedback in both online and paper-and-pencil formats. Survey questions targeted students' reflections on their use of Facebook as an educational online medium in postsecondary courses. In the first stage of data analysis, Likert-scale items were summarized through frequency and proportion measures and related visual representations. In addition to demographic information, the remaining items were organized into three categories: prior Facebook experiences, insights into students' experience, and future online engagement. Entries were labeled using a reference number coinciding to the date (and time, in the case of online submission) of completion.

To analyze the survey data, a spreadsheet was populated automatically with the data from the web-based survey and manually from the paper-and-pencil version. To ensure reliability in the digital recording of students' textual responses, manually entered responses were checked by a second researcher following the initial data entry. In addition, the automatically populated spreadsheet was reviewed, both electronically and manually, for responses that were submitted and recorded twice in error, and such responses were removed. As well, to prevent any skew in the data, surveys with incomplete Likert-scale responses were removed.

In the second stage of analysis, keyword textual and thematic analysis was performed on participants' short response submissions (Creswell, 2007; Glesne, 2011). Keyword identification and sorting were conducted digitally, and then cross-checked manually to ensure that no keywords were misidentified or inadvertently overlooked. In line with our three research questions and survey design, themes for analysis were categorized as

1. Pedagogical advantages of Facebook,
2. Challenges to employing Facebook in education, and
3. Opportunities to address these pedagogical challenges.

RESULTS

Demographics and Prior Facebook Experiences

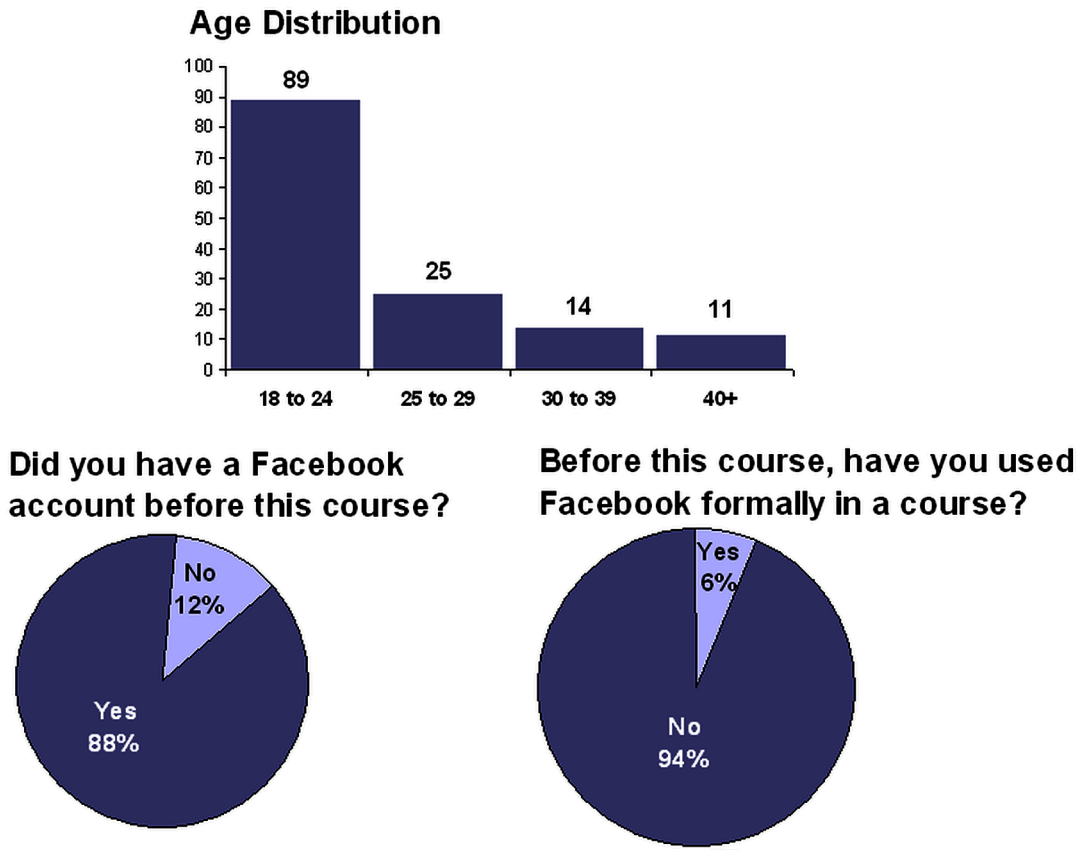
The demographic data for participating students, as well as their prior Facebook experiences, are presented in Figure 1. A majority (82%) were between the ages of 18 and 29, although participation in the survey reflected a considerable range of ages beyond this range. Eighty-eight percent had a Facebook profile prior to the start of their course, accurately reflecting the prevalence of student use of Facebook for social purposes. However, only about six percent (8 students out of 139) reported having used Facebook in an educational setting prior to their current course.

Interestingly, the previous two results stand markedly in contrast with data from earlier in our study; in the first phase of data collection, only 63 percent had a Facebook profile prior to the start of the course, while none of the students had used Facebook previously in an educational context. This substantial shift in prior Facebook use reflects two facets in the consideration of Facebook in educational domains: first, the popularity and prevalence of Facebook despite the rise of new social media; second, the subtle acceptance of Facebook in educational environments.

Likert-Scale Analysis: Insights into Student Experience

As illustrated in Figure 2, our frequency analysis of Likert-scale questions reveals that reactions of students (both graduate and undergraduate) towards the use of Facebook were largely posi-

Figure 1. Demographics and prior Facebook experience



tive. Seventy-one percent of the students agreed or strongly agreed that they enjoyed using Facebook during their course, reflecting significant engagement throughout. Ninety percent reported that Facebook is user-friendly, with about half strongly agreeing with this statement. Although this result is not surprising given students' prior experiences with Facebook, it is, nevertheless, indicative of one of the most attractive facets of Facebook as a learning medium: the relative lack of need for training and supporting users from a technical perspective. In consideration of Facebook as a collaborative medium, approximately 86 percent agreed with the statement: "Facebook is a strong Web 2.0 medium for interacting with others." Consistent with findings in the literature, these results collectively support the motivation of the authors of this research project in selecting Facebook as an educational learning media.

Likert-Scale Analysis: Future Online Engagement

Despite their overall positive response to the use of Facebook, students also signalled limitations in its use within a higher education environment. As illustrated in Figure 3, students were divided in their consideration of online learning as a component of their future courses. Only 65 percent of the participants preferred posting their responses in an online forum, and just over half stated that they would like to use Facebook again in future

Figure 2. Insights into student experience

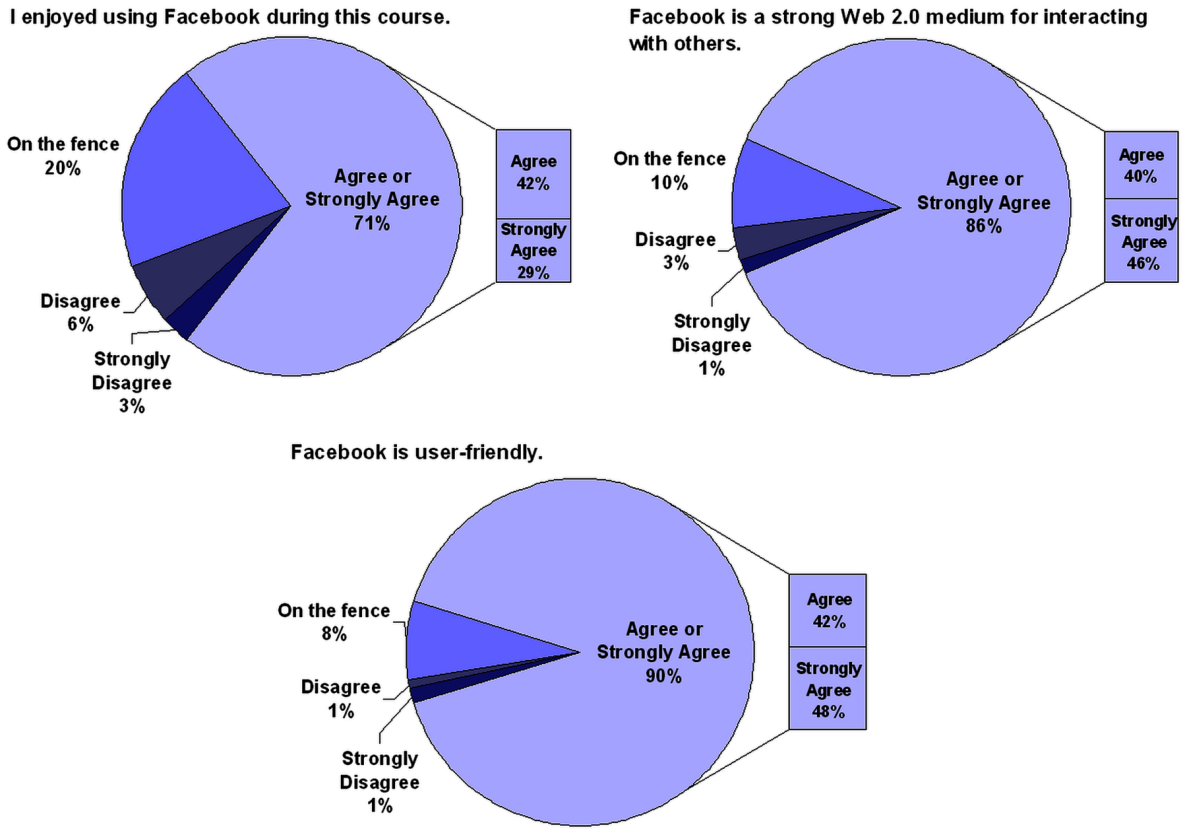
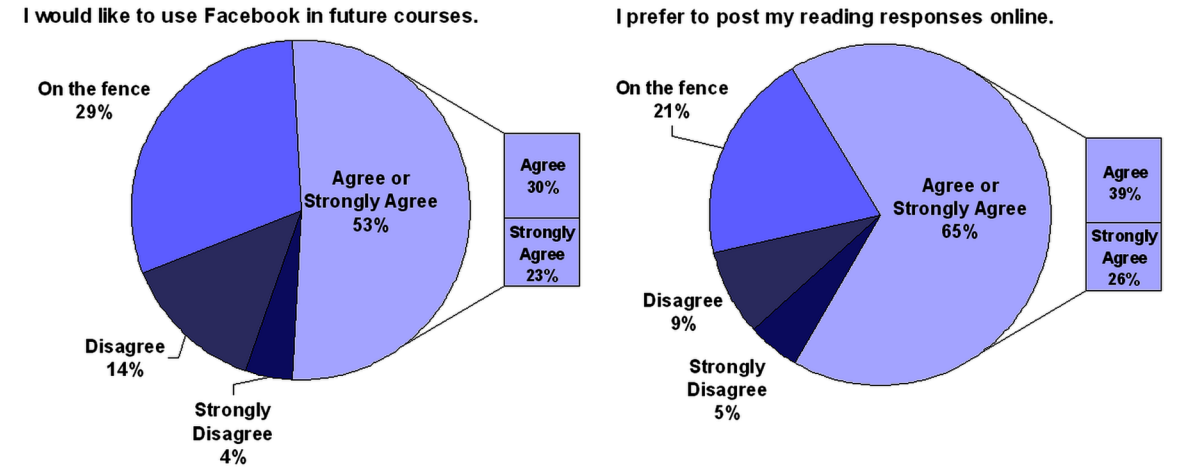


Figure 3. Future online engagement



courses. Viewed in contrast to the student experience data, these results suggest that there is a great need to investigate the underlying causes of the gap between, on one hand, students' hesitation towards employing Facebook as a component of academic courses and, on the other hand, their immersive and positive experience of Facebook.

Thematic Analysis 1: Pedagogical Advantages of Facebook

Students in this case study identified some of the advantages and key elements situating Facebook as an effective learning medium. Many of these elements are well aligned with responses to the Likert-scale questions previously outlined in this chapter. Students described Facebook as a user-friendly medium for collaboration, in that "extensions of classroom discussions are recorded, and can be referred back to." One student commented that, as a familiar forum for peer-to-peer and peer-to-group interaction, Facebook "provided an educational outlet to utilize an everyday social aspect of my life." The response from students was overwhelmingly positive towards the leveraging of a familiar social medium in educational settings.

Some students noted that sharing terse textual or visual contributions and creations in a non-threatening environment with peers encouraged them to complete course readings each week. Others also observed that they were completing readings more regularly than in other courses since they were responsible to the group; interestingly, given the social and visual facets of the Facebook discussion groups, some students likened them to an in-person study group where students are motivated by a "social responsibility" to one another. Students noted also that their interactions and responses to course materials could be represented through multimedia as well as text.

Our findings support previous work on Facebook's positive effects in higher education, in relation to:

- Removing barriers in the classroom (Schaffhauser, 2009);
- Encouraging peer support, acceptance, a sense of belonging, and social familiarity (Bowers-Campbell, 2008; Fewkes & McCabe, 2012; Selwyn, 2009);
- Increasing creative expression (Casey & Evans, 2011);
- Developing multiple literacies and skills (O'Keeffe & Clarke-Pearson, 2011);
- Encouraging use – and real-world bridging – of social media technologies (Blankenship, 2010); and
- Augmenting online community engagement (Madge et al., 2009).

DeAndrea, Ellison, LaRose, Steinfield, and Fiore (2012) note that students felt confident and valued when collaborating on Facebook, thus motivating the production of high quality work. Bala and Arat (2013) observe that the architectural studio supported with a social media network offers more opportunity for information exchange and presentation: sketches, technical drawings, perspectives, renderings, and mock-ups, along with virtual discussions and the opportunity to engage new partners, both locally and globally.

The benefits of using Facebook in higher education courses surpass functions such as posting assignment details, course information, upcoming events, and reminders. In our study, the Facebook pages enable students to share areas of interest and, by posting website links, newspaper articles, photos, blogs, YouTube videos, drawings, mock-ups, and so on, to link course topics to contemporary world issues, and to social and technical developments. While these capabilities are available in many popular postsecondary learning management systems, in our view it is the social investment that distinguishes Facebook from these other systems. Students are more actively engaged in the course content through Facebook compared to the traditional lecture style of teach-

ing and learning – even online – that continues to prevail in postsecondary education. Facebook enables students to participate in building course content and structure that diminish the hierarchy and bridge the gap between the position of the students and the role of the course instructor. Based on the students' responses to this survey question, the ability of Facebook to provide a platform for collaboration and knowledge sharing underscores its value as a plausible pedagogical medium.

Thematic Analysis 2: Challenges to Employing Facebook in Education

Challenges to Facebook's educational adoption emerged opposite the gains experienced through its use in the six courses. Despite our initial optimism towards this pedagogical trial, students identified several important challenges. For example, it was noted that, despite careful planning and course organization, Facebook remains, ultimately, a social medium and not an academic forum. Related to this, some students explained that Facebook was too distracting – due to their social presence – and lacked the legitimacy of other exclusively academic learning management systems: undergraduates were more bothered by this than graduate students. Some students were also concerned with security, privacy and ownership issues on Facebook. Within the class, students were apprehensive about classmates' access to their personal profiles, and beyond the class, students feared class-based interactions being visible by their non-course "Facebook friends." This point underscores the importance of students' digital personae and footprints even in the context of a course. External forces – such as a required component of a university course – could potentially damage or jeopardize a student's sense of (online) self. Students also raised concerns over the ownership of their postings once these appeared on Facebook – a concern that was related to the legitimacy of Facebook in education.

Finally, and perhaps most importantly, students also raised pedagogical concerns for the design and format of the Facebook groups. Small group size was cited by some as a deterrent to meaningful discourse: some students complained that their posts did not receive sufficient responses from others, and this served as a barrier to substantive discussions. Similarly, the asynchronous format of students' use of Facebook created tensions when an individual was not able to, or neglected to, post contributions in a timely manner prior to the related face-to-face class meeting. This concern, like that regarding distraction, was more problematic for undergraduate than for graduate students. Table 1 summarizes, in order of descending prevalence, the challenges expressed by participants in the one-year case study.

These results contribute to the extant literature on the challenges of using Facebook in higher education: it may be seen as non-educational (Bala & Arat, 2013; Fewkes & McCabe, 2012) or insufficiently formal for academic work (Madge et al., 2009); it may increase the incidence of "Facebook depression" (O'Keeffe & Clark-Pearson, 2011), distract from learning (Blankenship, 2010) and, in some cases, lower grades (Stollak, Vandenberg, Burklund, & Weiss, 2011); and it may give rise to a number of privacy issues (Charlton, Devlin, & Drummond, 2009). They also echo earlier suggestions that Facebook use in higher education courses might potentially blur the lines between the academic world and the social world (Judd, 2010).

Although there are many challenges uncovered by students (see Table 1), it is important to consider the nature of these. First, the two most prevalent concerns related to course design are facets over which instructors have almost complete control. Second, several of the challenges presented can be remedied through educating the students within a course on addressing Facebook policies and parameters, such as ways to adjust notifications and personal privacy settings. Many of the student participants in this research recognized these

Table 1. Challenges to employing Facebook in graduate and undergraduate courses

Challenge	Description	Prevalence in Data (Percentage of Responses Citing Particular Challenge)
Timing/ Sequencing	Asynchronous format of online discussion resulted in fragmented correspondence; responses from classmates were often not received in a timely manner.	20.9%
Small Group Format	Small group size challenged some students in finding meaningful dialogues with a variety of perspectives. Students felt that if their group was not thoughtful and reflective, they were at a disadvantage.	19.4%
Distraction	Students felt that Facebook, with its variety of uses and forms of social engagement was distracting to them while attempting to complete their assigned work.	10.8%
Privacy	Students expressed concerns over the privacy of their personal Facebook account after joining the discussion group. Students were concerned over access of others to their personal profile.	7.9%
Excessive Notifications	Students were concerned that excessive notifications were being sent to their email address, and although they acknowledge it was addressed and resolved during the course, it was identified as a challenge.	7.9%
Non-Academic Format	The nature of Facebook as a non-academic format (compared to other exclusively academic learning management systems) presented a challenge to a group of students.	5.8%
Security	A small number of students (n=2) expressed concerns over data control and ownership policies on Facebook.	1.4%

important points, and proposed suggestions for improving their experience of using Facebook as a key part of their learning.

Thematic Analysis 3: Participatory Strategies to Address Pedagogical Challenges

Identifying challenges in working within the blended course structure, and especially in using social media as a learning forum, gave students an opportunity to participate in the design of pedagogical strategies to improve the adoption of Facebook. First, students requested greater clarity in instructions for posting requirements and conventions: they wanted firm guidelines about how to title a post or multimedia contribution and when to start a new "thread" in a discussion instead of replying to an existing thread. They also requested that discussion group membership be reorganized and rotated at intervals during the course to ensure variety in discussions. Although audio and video postings were encouraged, students wanted non-textual posts to be given a more prominent place. Finally, although the instructor's role was initially one of facilitation, many students requested a more participant-expert approach, whereby the instructor would determine validity in discussions.

Both graduate and undergraduate students in our case study welcomed the opportunity to contribute to feedback about, and enhance Facebook usage in relation to, their university learning experience. Their responses suggest a strong interest in the collaborative development of Facebook as a learning medium that is appropriate for their blended learning usage. Over the course of the case study, this feedback has been used to inform the course instructor's pedagogical decision-making, and the ever-evolving design of the courses. This experience reveals the importance of including students as participants with significant input and contributions to the development of a successful learning environment, a finding consistent with

the shared leadership and valued contributions emphasized in the theoretical frameworks that inform this research.

This aspect of the research presented in this chapter is particularly significant for two reasons. First, it directly informs future iterations of courses taught, and the continued use of Facebook as a medium for learning. That is, it allows course instructors an opportunity to reflect on their own practice and consider the informed suggestions of students who have been experiencing the use of Facebook firsthand. Second, it allows students the opportunity to engage in a reflective practice that is central to their development across university fields and disciplines. The ability to reflect upon, develop, and improve the facilitation of social media collaboration is an essential skill in both articulating and meeting the needs of 21st century learners, particularly in regard to the built environments and situated practices of engineering and architecture education.

RECOMMENDATIONS FOR COURSE DESIGN AND IMPLEMENTATION

Following the recommendations of students, as well as the feedback garnered from both informal and formal discussions throughout the research, we offer some strategies toward a more effective implementation of this blended learning model. Table 2 lists the challenges first presented in Table 1 and detailed in the first thematic analysis. Opposite these challenges are relevant and related recommendations. These can be conceptualized as three connected initiatives. First, course instructors are encouraged to *clarify* expectations for online engagement at the start of a course, and throughout, to ensure that students are aware of the expected level of involvement as well as the required conventions. Second, instructors are encouraged to provide students with *choices* for their navigation of the course material, including types of Facebook interactions – texts and multimedia – in an effort to maintain student engagement, encourage the learning of new skills, and combat distraction. Finally, instructors are encouraged to actively *educate* their students regarding the policies and settings of social media employed in their courses, and ultimately to equip students with the skills they need to locate and navigate these settings on their own. What follows is a graphic table organization of these findings; recommendations are listed in descending order of frequency prevalence.

OBSERVED TRENDS

The social media phenomenon has spawned social change (Mason & Rennie, 2008), and the use of Facebook, YouTube, Twitter, Instagram, and other current technologies in higher education is a testament to that change. Our results suggest that a majority of students are willing and ready to incorporate social media such as Facebook into their undergraduate and graduate education. Educators are already aware of how students are using social media to find resources and validate ideas through others (Bowers-Campbell, 2008). The next step is to embrace these existing skills, in order to help students recognize that "non-formal" literacies are bridges that can expand and improve formal academic practices (Buckingham, 2008; Lankshear & Knobel, 2008) – particularly for engineering and architecture students whose academic work overtly interlinks the formal learning environment with informal learning in situated practice (Cochrane & Rhodes, 2013). Research indicating the positive effects of social media on teaching and learning, for both students and instructors, will bolster the incorporation of social media technologies in higher education.

While Facebook is relevant for educational practitioners and professionals, social media integration into higher education institutions, and especially students' educational use of Facebook, requires more research (Bala & Arat, 2013). While current empirical evidence sug-

Table 2. Recommendations for Facebook course design and implementation

Challenges to Implementation	Recommendations for Course Design
Timing/Sequencing Asynchronous format of online discussion resulted in fragmented correspondence; responses from classmates were often not received in a timely manner.	Ensure that students are aware of posting expectations, including an expectation of the latest that a posting may be submitted to facilitate an opportunity for discussion. Monitor groups regularly and educate those that are not meeting expectations in the importance of timely contribution to the success of a collaboratively-generated space.
Small Group Format Small group size challenged some students in finding meaningful dialogues with a variety of perspectives. Students felt that if their group was not thoughtful and reflective, they were at a disadvantage.	Reorganize discussion groups and rotate during the course to ensure a variety of voices exist in discussions.
Distraction Students felt that Facebook, with its variety of uses and forms of social engagement was distracting to them while attempting to complete their assigned work.	Clarify that students are allowed to create a new Facebook account under a clearly identifiable pseudonym for use only with the course to prevent and limit distractions. Provide students with more opportunities to post non-textual content as their weekly posting. This can support engagement (and combat distraction) in a non-punitive manner.
Non-Academic Format The nature of Facebook as a non-academic format (compared to other exclusively academic learning management systems).	Provide more clarity in instructions for posting requirements and conventions to further clarify expectations. Increase the presence of the course instructor on group pages, without compromising the autonomy of the student space.
Privacy Students expressed concerns over the privacy of their personal Facebook account after joining the discussion group. Students were concerned over access of others to their personal profile.	Educate students through peer research and review of Facebook policies and terms on: • Access within and beyond a closed Facebook group, and how co-enrollment in a group affects access to others' personal Facebook pages. • How to control notifications from a group on Facebook, to ensure that one receives the notification emails they want and block those that are unwanted or excessive. • Ownership of information and materials (including postings) placed on Facebook. • Measures taken by Facebook to ensure the data integrity of their servers with respect to the protection of the personal data of users.
Excessive Notifications Students were concerned that excessive notifications were being sent to their email address, and although they acknowledge it was addressed and resolved during the course, it was identified as a challenge.	
Security A small number of students (n=2) expressed concerns over data control and ownership policies on Facebook.	

gesting that students are open to using Facebook (and other social media technologies) in formal academic settings can inform the pedagogical use of Facebook as a successful alternative to more traditional learning management systems, there is a scarcity of longitudinal, comparative studies of how Facebook is being used in higher education institutions for formal educational purposes, as well as of research on the evolution of Facebook use in postsecondary courses, and on the insights of undergraduate and graduate students regarding its use in academic settings. Further consideration is needed in regard to the support structures necessary for instructors and students to use social media and social networking as learning fora and to maximize their impact. These avenues of research must also look at how e-learning platforms can effectively translate across disciplines throughout the academy: they must be flexible in form and function so as to allow the forward movement of technology enhanced e-learning while ensuring that student engagement and participation remain at the forefront of pedagogical goals – whether in architecture, engineering, or other disciplines.

We chose Facebook as a representative application of social media that has been widely adopted amongst postsecondary students, such that our students were already situated as experts in its use.

Graduate and undergraduate students in this case study embraced Facebook as a learning medium, and their engagement signalled their acceptance of this novel avenue. However, despite students' expert knowledge, education regarding privacy and security is still essential to implementation. Addressing misconceptions around closed groups on Facebook and access to an individual's personal information is crucial to this process. The importance of these security concerns will rise in relation to the intellectual data that is being shared or expressed online, since even frequent Facebook users may be unaware that account privacy settings and notifications can be customized. In light of all of this, as we have highlighted here, feedback from students will continue to inform the subsequent iterations of Facebook across higher education.

The fact that a majority of students in this case study were willing to incorporate social media into formal higher education suggests that educators might usefully leverage students' existing social media strengths to recognize out-of-school, non-formal literacies as bridges for improving formal academic practices. Following, illuminating and assessing the development of skills, knowledge, understandings, and possibly new methodologies for thinking (Schmidt & Cohen, 2014) may help strengthen and enhance the positive effects of social media incorporated into and across higher education pedagogy.

What is next for situated, social media education? Facebook can be used in conjunction with other Web and social media technologies, such as YouTube, Twitter, Instagram, Google Drive, and so on. As noted, this case study is the second phase of a longer-term study researching Facebook use in higher education. At the time of writing, this research is continuing with the intentional incorporation of these technologies into the social media blended learning model; the goal of our third phase of data collection, along with a comparative analysis of data collected during the first two phases, will be to trace the evolution of social media use over the span of this work. There is a need for more extensive studies on higher education students' use of Facebook and other social media – tracing student-instructor interactions on social media, and exploring deeper ways of thinking – as well as comparative and longitudinal studies on the use of Facebook and other social media as components of a blended learning medium. This is particularly so in engineering and architecture education, where an essential aim is to better facilitate connections between the built environment and "knowing in action" (Schon, 1987), thereby building bridges between the formal academic learning environment and the informal learning environments of situated practice (Cochrane & Rhodes, 2013).

When discussing the needs of 21st century learners, it is critical to consider the 21st century world of experience that they will be entering. Technology enhanced collaboration is increasingly becoming a required skill in the workplace (Griffin, 2012; Jenkins et al., 2013). Studying the use of social networking (including Facebook) within a blended course design has the potential not only to target the specific skills required for individual success after leaving a formal higher education environment, but also to inform a more global study of similarly networked and interconnected professional and economic practices.

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KEY TERMS AND DEFINITIONS

Blended Learning: The integration of face-to-face and online approaches to education.

Multimodal Learning: The use of multiple stimuli in a learning experience. With multiple modes of expression in the digital age, auditory, visual, and tactile senses are being employed simultaneously in the intake of information.

New Media Technologies: Increased access to content in the digital age, characterized by creative participation, asynchronous contribution structures, and interactive user feedback.

Participatory Culture: A culture in which private individuals do not act as consumers only, but also as contributors or producers, that enables people to work collaboratively.

Postsecondary: A level of learning that is generally offered through universities, colleges, or institutes. These programs offer diploma or degree options.

Social Media: The social interaction among people in which they create, produce, share, or exchange information and ideas through virtual communities and networks.

Social Network: A platform to build social relations among people who share ideas, interests, activities, backgrounds, or real-life connections.

Chapter 20
Interactive Learning System for Primary Schools using Tablet PC

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ABSTRACT

The rapid development in technology has facilitated human beings in many ways such as automated home appliances, smart vehicles, smart mobile phones, and tablet computers. The uses of these tools and techniques are increasing in our daily lives to facilitate day to day work. The new trends in technology have focused on finding approaches towards improved learning techniques. Various tools are being used to integrate Information and Communication Technology in education. Tablet Personal Computers (PCs) are one of the new and innovative tools used in education for enhancing learning skills. This research has been conducted in five primary schools, where students of class nursery to class three were taught basic lessons using Tablet PC. In this research an application has been developed on android platform with easy to use interface, where the students were able to perform simple arithmetic calculations and learned alphabet of Sindhi and English languages in visual form. During the experiment, it was observed that with visual aids students understood lessons more clearly and easily.

INTRODUCTION

The use of technology-oriented tools such as Tablet PC and smart devices in education sector has increased at rapid pace since last few years. Johnson et al. (2013) have forecasted the common use of Tablet PC and other interactive tools in higher educational institutes of developed countries in next one or two years because of their ease of use and increased learning. However, interactive tools have already been adopted in few schools and colleges of the developed countries in order to transform their educational system.

It has been witnessed that the use of technology is not only aimed for engaging students and making learning a fun but it also enhances technical and information literacy skills of students (Enriquez, 2010). Recently, the use of mobile devices with internet access has increased vastly in education for providing contextual motivation and information

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gathering at any time. Interactive learning applications can be used to transform learning process from traditional paper-pencil based methods to digital tools (Dundar and Akcayır, 2014).

Majority of schools in Europe, Thailand, Malaysia, Singapore, Japan and Korea are integrating Tablet PCs and other smart devices into their educational systems and nowadays much emphasis has been put to create innovative skills among students than ever (Koh and Lee, 2008; Hyo Jeong, 2012) . Majority of the researchers think that schools should develop creative skills for students using interactive learning tools (Roblin et al., 2013). Various interactive learning projects using Tablet PCs have been implemented at the primary school level in the mentioned countries, which aim to provide quality education to the deprived groups of children such as those living in the impoverished rural areas (Mario and Domingo, 2012). The US and Turkish governments have initiated interactive and technology oriented projects with a large amount of budget in their educational system in order to provide equal learning opportunities to students of all regions (Crompton & Keane, 2012; Lewin & Luckin, 2010; Eren & Izmirli, 2012; Fri-tic, 2012). However, majority of public sector schools in the Sindh Province of Pakistan have shortage of resources and lack access to the quality education. Moreover, the existing learning resources implemented in educational system of Sindh province don't provide any interactive mode of learning i.e., books cannot produce any sound when the finger is moved or touched on particular text or image. There is also shortage of technology-oriented resources such as computers at primary schools of Sindh Province.

Keeping in view the use of technological tools in developed countries, if Tablet PCs and other interactive tools are incorporated into the Education System of Pakistan, particularly in Sindh province, then they may enhance the learning skills of students.

1.1 Objectives of the Research

The most important objective of this research is to introduce new mode of learning in the primary schools of Sindh province using Tablet PCs. Tablet PC is said to be a digital slate or white board which is nowadays most commonly used tool in educational systems of developed and many other countries. Further objective of this research is to make learning as a fun by developing interactive user friendly application including Sindhi, English alphabet letters, number counting and mathematical calculation lessons and measure the effectiveness of the technological use by students.

1.2 Scope and Limitations of Study

Students of primary level can use this application in order to learn in easier way. Non-enrolled students can utilize this application at their homes for enhancing their learning skills. Even illiterate adults, particularly the girls who cannot attend the schools due to various reasons may utilize this application at their homes for getting/enhancing education. Government organizations or NGOs who are working for enhancing the literacy ratio in Pakistan can also use the findings of this research. This research study was conducted only in five primary schools, where 269 students and 22 teachers participated. Also this research study is focusing only on students of primary level.

1.3 Research Questions

The research questions to be answered under this study are: What effects the Tablet PC will have on the learning of primary school students? What are the perceptions and attitudes of students and teachers for the implementation of Tablet PC as a learning tool? How learning techniques can be made easier for primary school students?

1.4 Chapter Organization

This chapter consists of five sections. Section 1 outlines the introduction of interactive learning systems using Tablet PCs in education, their need and significance. Section 2 reviews and outlines the background work already done for the purpose of the study. Section 3 presents the research methodology and outlines research design, collection and analysis of data, selection of sample schools and the development of application. Section 4 presents the results of application tests by participants. Section 5 gives the conclusions and future work.

2. BACKGROUND

The widespread research studies conducted for the incorporation of Information Technology based devices in education has shown positive impact towards the learning process of students. It has been shown that, by incorporating IT tools and techniques in classroom, teaching and learning have provided interactive and increased learning environment. Different technology oriented tools and techniques are being used by various developing and developed countries to improve their primary level school education (Hyo Jeong, 2012). One of the newly and commonly used techniques among them is the use of the tablet PC (Personal Computer) technology for interactive and collaborative learning. A little academic research has been carried out for the use of interactive tools in education. According to the research study of Ghavifekr (2011) and Freedman and Dalton (2012), the Tablet PCs and other interactive devices increase the engagement, motivation, concentration, self-guiding and group learning of students. Also from teachers' perspectives, the Tablet PCs facilitate students' development by enhancing their creativity, communication and digital literacy abilities (Roblin et al., 2013).

It is required that there may be a defined framework in order to guide students for learning the right things at the right time and students may have a freedom for learning. A pedagogical framework suggested by Dundar and Akcayır (2014) provides a significant tool to the teachers for planning and evaluation of mobile phones and other interactive tools used in education.

Research conducted by Heinrich (2012) found that when incorporating Tablet PCs in education, it is required to choose certain subjects which may be learnt in better way using interactive devices such as iPads and Tablet PCs. Tablet PCs and the iPads support various applications which are used to learn English, Mathematics and other Science subjects. However, iPads have drawbacks of platform independent support of applications; they don't support android or other platform based applications.

According to the research study conducted by Kowalski, F.V., Gok, T. and Kowalski, S.E (2009) regarding the integration of Tablet PCs in education, it is suggested that Tablet PC use may enhance the problem solving abilities of students. After completing the required activities students can also get feedback and make them prepared to tackle the problems in a better way.

The Tablet PCs provide a useful way to apply them for collaborative and interactive learning. Recently various uses of the tablet PCs in classrooms include: active learning in mathematics (Romney, 2011; Reba and Weaver, 2007) interactive software design (Simoni, 2011), e-ink and note taking (Tront, J.G, 2011), engineering and computer science classrooms (Lisa et al., 2007), in-class assessment based on tablet PC (Rogers and Cox, 2008), as an instructional tool for learning English in those countries where it is taught/spoken as a foreign language (Savas Perihan, 2014) and classroom based collaboration using Tablet PC (Anderson et al., 2007).

As it is shown in the background study, with the growing demand of Tablet PC in the classrooms, it is convincing to realize, how such types of applications can be helpful for improving the learning abilities of students.

A research study conducted at Virginia Tec USA by Kothaneth et al. (2012) suggested that students who are learning through Tablet PC feel very easy to read / write lecture material because of its visual form. Students would also be capable to playback the same lectures at any moment / time if required.

An evaluation study "Tablets for Schools" being conducted by Clarke & Svanaes, (2013) showed that Table PCs are used to provide facilities of collaborative learning, where students can learn at their homes and they can discuss school work with other pupils at their homes as well. According to the teachers' observations, Tablet PCs provide opportunities to students to continue their work at their homes in order to break down the gap between school and home and make communication easier. Students have greater motivation for learning and they can be creative. The Tablet PCs provide variety of learning styles to students. Students also enjoy the collaborative learning methods. When students discover any new idea on the iPad or Tablet PC, then they share it with other students (Goodwin, K, 2012). The sharing of information among students in this way is very helpful in collaborative learning.

According to UNESCO report 2013, only about 56% of Pakistani adults are literate (Pakistan's High Illiteracy Rate Threatens Its Fragile Democracy, 2013). Comparing this ratio with the literate adults of our neighboring countries like India and Sri Lanka their adult-literacy ratio is 74% and 97% respectively. The adult-literacy ratio is even worst in the rural areas of the Pakistan, where approximately 70% adults are illiterate with girls in majority.

A new literacy policy initiated by the government of Thailand called "One Tablet Per Child" (OTPC) has been launched in June, 2012 for improving the ratio and quality of education at primary level. To initiate the project, more than 800,000 tablet PCs consisting of more than 336 learning applications installed were distributed among the primary school students of grade one (Viriyapong and Harfield, 2013). However, the OTPC policy has design and course contents problems. The American government has started "Bring Your Own Device"(BYOD) policy for primary school children which has shown positive improvement in the learning of children (Tierney, 2012). This literacy policy has a problem that the students having devices (mobile phones, laptops, tablet PCs, PDAs, iPads and iPhones) which are of different types with different application running on them. In our research we have focused on the use of same device (Tablet PC in this research) for all the children that run the same application. It was found that this approach is very useful for students in order to learn things more quickly and easily.

A research study was conducted by University of Hull in collaboration with Scottish government for measuring the affordability and efficiency of Tablet devices such as iPads in education. The research study concluded that with the use of Tablet devices such as iPads, many major elements required for the excellence curriculum framework are achieved. The study also found that, integrating Tablet devices in education provide many benefits such as engagement and motivation of students is increased and parental involvement has also increased. It was also shown that students can understand complex problems or complex ideas more clearly using such devices. Furthermore, it was also observed that the use of Tablet devices can be more beneficial if these devices are owned by students. This single factor of ownership will make the use of Tablet devices successful in education (Burden et al., 2012). Although this research study is encouraging for the use of Tablet devices in education, however it also has some issues like; the ownership of the devices by students can cost more. Students can purchase Tablet devices of different brands which may result the problem of software support due to platform dependency.

Many research studies show that learning through Tablet PC is much easier than traditional pen and paper based learning (Cao.H, 2014). Twin-

ing and Evans (2005) Proposed that students can adopt learning styles more easily and quickly using Tablet PC. Another research study conducted by (Galligan et al., 2010) suggests that the Tablet PC provides a facility to draw or sketch any diagram easily, so students can draw Mathematical equations or complex shapes more easily.

The Tablet PC has capability to store many resources i.e.; notes, books, lecture material etc. at one place. Ifenthaler & Schweinbenz (2013) and Koshelva et al., (2006) in this connection suggested that Tablet PC is like a portable classroom providing the facility to students to learn at any time and place.

Students learning through Tablet PC has proven to make learning as a fun and enjoyable as well as it makes the learning as a personal (Bjerede and Bondi, 2012). They are becoming motivated for learning because of increased attention and interaction. It suggests that Tablet PC has positive impact towards the learning outcomes. It also improves the confidence of students (Enriquez, A.G., 2010; Roblin et al., 2013).

As it is evident from literature reviewed that the learning techniques are going to be shifted from printed text to electronic text. This research study also shows that the Tablet PCs have become integral part in education for learning and teaching in various schools of developing and developed countries.

3. METHODOLOGY

In this research study, an application is developed and a usability test is conducted with 291 participants, including students and teachers. Furthermore, the pre and posttests questionnaires were filled by the test participants. The questionnaires were focused on the impact of interactive learning systems using Tablet PC in primary education for enhancing learning abilities of students. Figure 1 shows the overall research framework followed in this research work.

3.1 Sindhi Language Alphabets

The Sindhi Language is based on 52 alphabet characters taken from Perso-Arabic script. Majority of characters are taken from Arabic scripts, few are taken from Persian and others are modified letters (Leghari, M., & Rahman, M. U., 2010). Figure 2 shows the list of Sindhi alphabet characters.

Every letter of Sindhi alphabet can be represented by one or two separate Unicode points; for example, "ال" can be written in Unicode as "FEFB" or it can be represented using two separate Unicode points "0627" for "ا" and "06F1" for "ل" respectively (Sindhi, n.d.). Individual letters of Sindhi alphabet are joined together to make a word (Ismaili, et al., 2014). Figure 3 shows the complete catalog of Sindhi letters, their equivalent Unicode points and names of variables in Sindhi language.

3.2 Selection of Schools

The schools for usability tests were selected on the basis of availability of computing resources. Three private and two government schools were selected for testing the application. In private schools the computer is taught from the class one and onwards, so in these schools most of students were familiar about the use of computers. However the government schools don't give computer education, therefore, students were not familiar about the use of computers.

3.3 Sample of Students and Teachers

This research was conducted with 22 teachers and 269 students including 90 students of nursery

Figure 1. Research framework

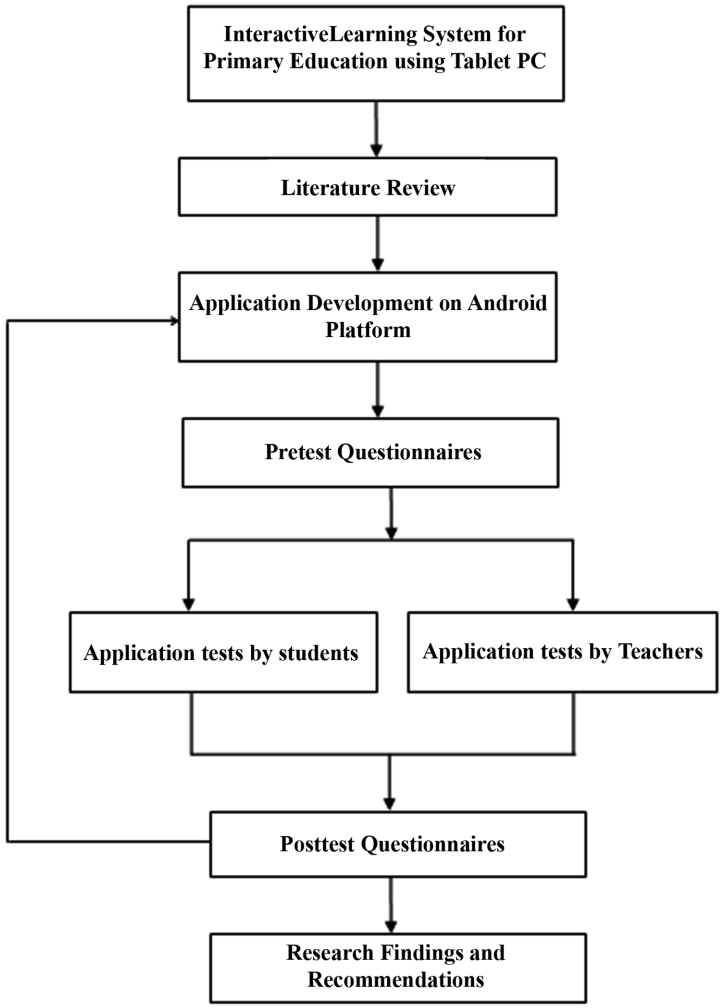


Figure 2. Sindhi language alphabet characters
(Leghari, M., & Rahman, M. U., 2010).

ا ب ٻ پ ت ٽ ٺ ٿ ٽ ٺ ث ٹ ٽ ق ج ڄ جھ چ ڇ ح خ د ڈ ڈ ڈ ڈ ذ ر ڑ ز
س ش ص ض ط ظ ع غ ف ق ڪ ک گ ڳ گھ ڱ ل م ن ڻ و ھ ء ی

class, 75 students of class level one, 58 students of class level two and 46 students of class level three. The priority was given to those students who had knowledge of operating smart mobile phone or computer. The questioners were designed to be asked about the quality and feedback of the research. Although most of the teachers were familiar about the use of computers and smart devices in their daily life, yet, they were given a short training about the use of application on the

Figure 3. Sindhi letters and their unicode points
(Ismaili, et al., 2014).

Variable Name	Unicode	Sindhi Letter	Veriable Name	Unicode	Sindhi Letter
sheen	0634	ش	alifMadA	0622	آ
swad	0635	ص	alif	0627	ا
dad	0636	ض	beh	0628	ب
toye	0637	ط	beeh	067B	ٻ
zoye	0638	ظ	peh	067E	پ
aieen	0639	ع	beheh	0680	ڀ
ghain	063A	غ	the	062A	ت
feh	0641	ف	theh	067F	ٹ
peheh	06A6	ڦ	mytheey	067D	ٽ
qaf	0642	ق	tteheh	067A	ٺ
Kaf	06AA	ڪ	ttay	062B	ٿ
keheh	06A9	ک	jeem	062C	ج
gaf	06AF	گ	dyeh	0684	ڄ
geuh	06B3	ڳ	nyeh	0683	ڃ
ngoeh	06B1	ڱ	cheh	0686	چ
lam	0644	ل	cheheh	0687	ڇ
meem	0645	م	hah	062D	ح
noon	0646	ن	khay	062E	خ
rnoon	06BB	ڻ	dal	062F	د
waw	0648	و	dahal	068C	ڌ
heh	06BE	ھ	dhal	068F	ڈ
hamza	0621	ء	ddal	068A	ډ
Yeh	064A	ي	ddahal	068D	ڍ
yehSmall	06C1	ہ	zal	0630	ذ
yehHamza	0626	ئ	reh	0631	ر
Min	06FE	ﷺ	rdeh	0699	ڑ
sindhi Ampersand	06FD	؆	zeh	0632	ز
			sceen	0633	س

Tablet PC before the start of usability tests. The teachers were allowed to answer the questions in order to make the research results more clearly.

3.4 Curriculum Development

The curriculum has been developed according to the curriculum being followed by the primary schools in Sindh Province. The developed lessons were categorized according to the grade level of students, which helped to determine the sequence in which the lessons were presented to students for learning purposes. Initially the lessons were developed for students of nursery, class one, two and three levels.

In order to bring attention of students, the user interface of the application has been designed to be very simple and easy to use. The user interface of the application is multi-modal consisting of audio, visual images and text for each letter of the alphabet.

3.5 Application Tests and Observations

The developed lessons were evaluated/tested by students of targeted classes i.e.; nursery, class one, two and three. The developed lessons were also evaluated by the teachers who were teaching to students of mentioned classes.

3.7 Feedback

The feedback from the concerned teachers and students is taken into account to further update the lessons and make them more improved. Feedback on the user interface design, on which these lessons have been designed, has also been taken in to account. According to the feedback of teachers, the user interface of the application is quite simple and easy to use.

4. RESULTS AND DISCUSSIONS

Table 1 shows research context describing the number of students, their class level and the number of teachers who were teaching in these classes. Most of the activities developed were targeted for students of nursery and class one level which consisted of Sindhi and English language alphabets, number counting and basic mathematical tasks. Each activity consists of sound, visual image and text of every letter of alphabet. However few activities were also developed for class two and class three level students as in private schools of district Shaheed Benazirabad, the Sindhi language is taught at class two and three level.

Data in Figure 4 shows the ratio of students who were familiar about the use of the computer. Most of students and teachers of the government schools had also either little bit or no familiarity about the use of the computer. The technology-oriented infrastructure should also be made available at government schools and it is necessary that the teachers of government schools may also be provided basic computer training.

Figure 5 shows the ratio of students who were familiar about the use of mobile device (either smart device or any other). The ages of students of class level two and three were between 6 to 8 years, so most of them were familiar about the basic operations of mobile device, however up to 60% students of nursery and class one level were

Table 1. Research context

S.No	Class Level	No. of Students	No. of Teachers
01	Nursery	90	08
02	Class One	75	05
03	Class Two	58	05
04	Class Three	46	04

Figure 4. Familiarity about the use of computer

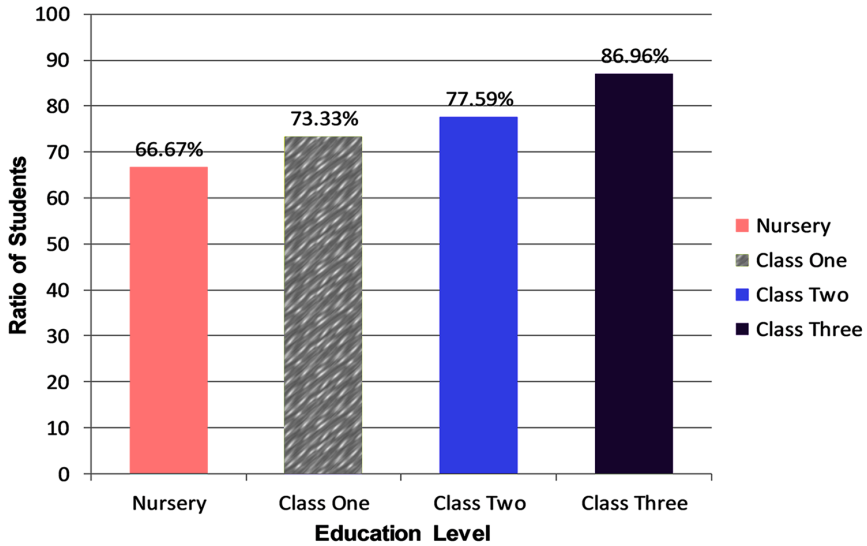
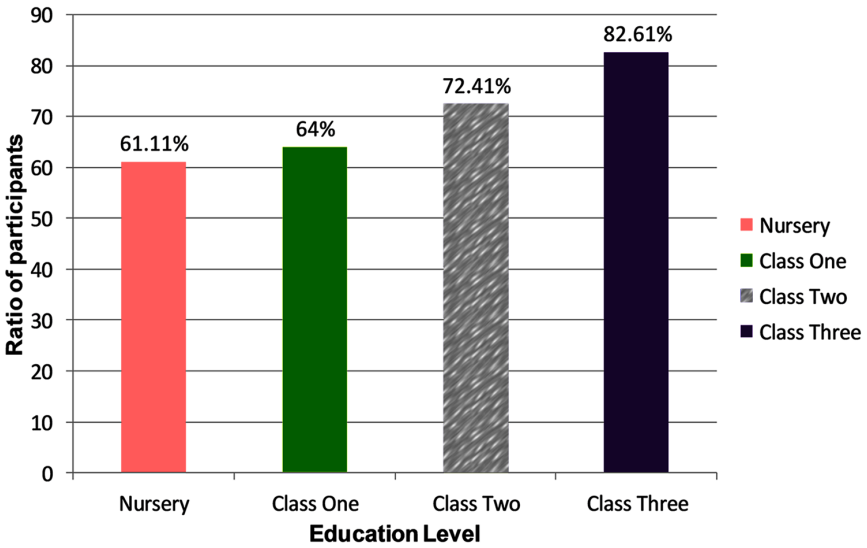


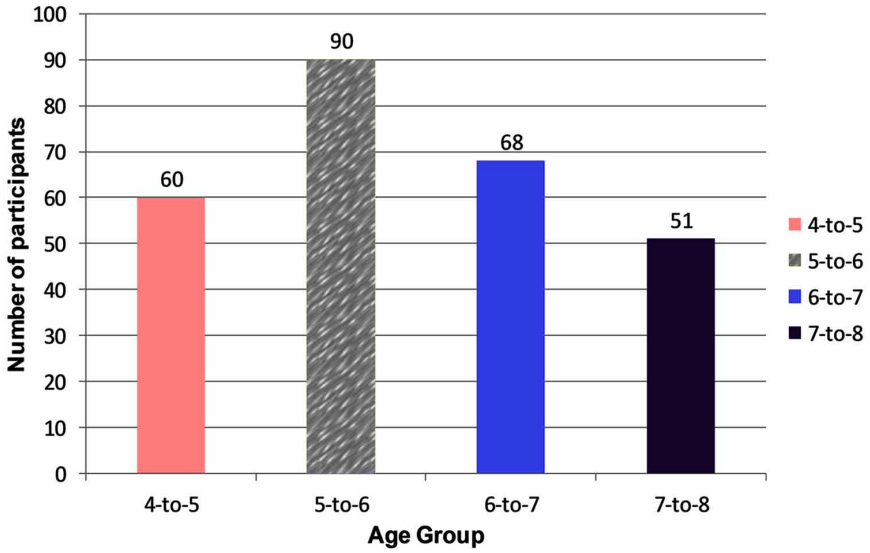
Figure 5. Familiarity about the use of touch screen devices



familiar about the use of touch screen devices. During the usability tests it was observed that majority of students were not feeling difficulty in operating Tablet PC, as it has touch sensitive user friendly interface which is easy to operate.

Data in Figure 6 shows the age group of the participating students. There were 60 students of 4-5 years age, 90 students of 5-6 years age, 68 students of 6-7 years age and 51 students of 7-8 years age respectively as shown in following figure. Students of age 6-7 and 7-8 years were studying in class two and three respectively. However in private schools the Sindhi language is taught from class two and class three levels, therefore these students were selected for usability tests.

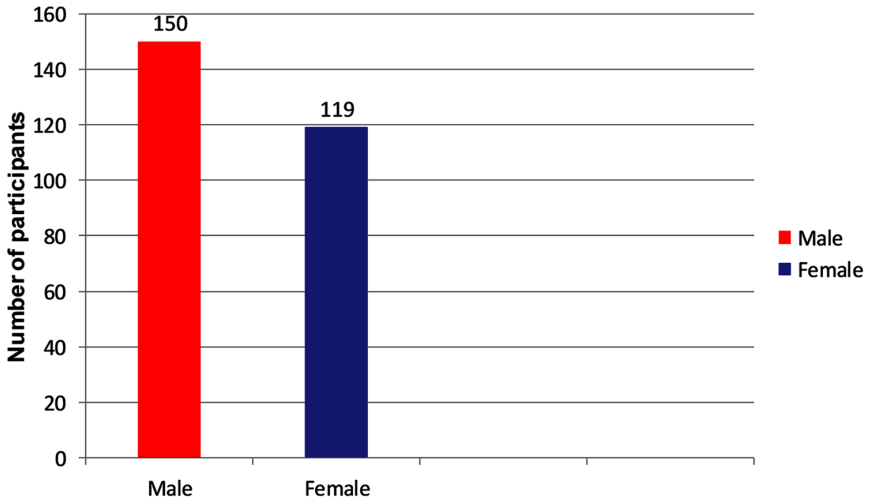
Figure 6. Age group of participants



Data in Figure 7 shows the number of male and female participating students who were selected for the usability tests. Both the boys as well as girls students were selected for usability tests.

After demographic measures, few practical tasks were assigned to students. There were eight activities made for this research. Among them four activities were consisting of Sindhi language alphabet letters, one activity was based on English alphabet letters and three activities were based on number counting and mathematical calculations. The activities consisting of Sindhi and English alphabet letters were lengthy, as each activity consisted of 52 letters of Sindhi alphabet and 26 letters of English alphabet. Each activity was showing only one alphabet letter along with the visual picture and text letters which were showing equivalent Sindhi and English words. Each

Figure 7. No. of male and female participants



activity also consisted of audio sound of Sindhi and English alphabet letters respectively. When the button was pressed for next activity's letter, the audio sound of the letter was played automatically. Figure 8 shows the task no. 1 which was performed by students of nursery, class one, two and three level.

Figure 8. Task no. 1

4.2 Tasks

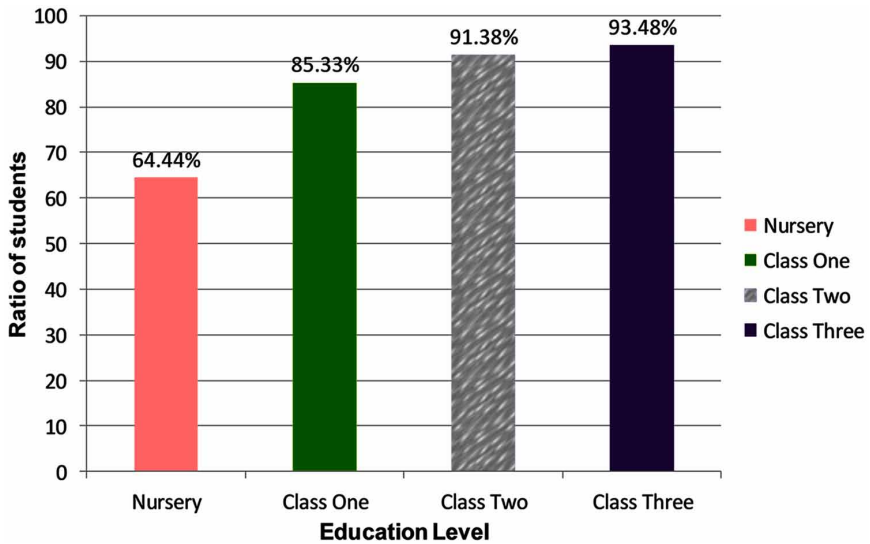
Various tasks were performed by students and below are the most import tasks. It was observed that students using Tablet PC memorized the task more easily and quickly as compared to other students. Each letter of alphabet is shown in visual form along with an image and background sound, so students felt it easy to memorize the letters in visual form and recognized them on the basis of audio sound.

Task #1: To find out the Sindhi Alphabet Letter "Te Taro" with Button Click.

Data in Figure 9 shows the ratio of students from nursery to class three who completed the task no. 1 successfully.

As the data in above figure shows that 93.48% of students of class three, 91.38% of students of class two, 85.33% of students of class one and 64.44% of students of nursery class completed the task no. 1 easily. The first letter of the Sindhi alphabet was displayed at the startup of activity. Separate graphical buttons were designed for moving to next or previous activity as well as

Figure 9. Ratio of students completing task no. 1



for home activity as shown in the user interface of Figure 8. Students of nursery class and class one were feeling hesitation in pressing the button for next or previous activity, so they were taking more time to complete the required task. However students of class two and three levels were not feeling much hesitation in pressing the buttons, so they completed the required task quickly. Table 2 shows the average time taken by each class to complete the task no. 1.

The results of Table 2 show that students of nursery and class one took more time as compared to other students of other classes. Most of students of class three were familiar about the touch screen interface.

Task #2: To find out the Sindhi Alphabet Letter "Te Taro" with Finger Swipe.

Figure 10 shows the task no. 2 performed by students of nursery, class one, two and three level.

Data in Figure 11 shows the ratio of students from nursery to class three who completed the task no. 2. Task no. 2 is similar like task no. 1, however its user interface does not use any graphical button and its working is based on finger swipe.

Figure 10. Task no. 2

Table 2. Time taken for completing task no. 1

Task #1	Nursery	Class One	Class Two	Class Three
Time taken (Seconds)	35-40	30-35	20-25	12-16

As the data in above figure shows that 100% of students of class three, 96.55% of students of class two, 96% of students of class one and 83.33% of students of nursery class completed the task no. 2 easily. This task was based on finger swipe technique. Next or previous activity was displayed using finger swipe at any area of the user interface. Students were feeling very easy to move to next or previous activity with their finger swipe. Even students of nursery class did not feel any hesitation to operate the Tablet PC with finger swipe. Table 3 shows the time taken by students to complete the task no. 2.

The results of Table 3 show that the students of nursery and class one took less time as compared to time taken for completing task no. 1. Here user interface of task no. 2 was easy to use. Also students of other class levels took less time to complete the task no. 2. Table 4 shows the comparison of task no.1 and task no.2.

Table 4. shows that the ratio of students of same level performing task no. 2 is higher than the ratio of students of same level performing

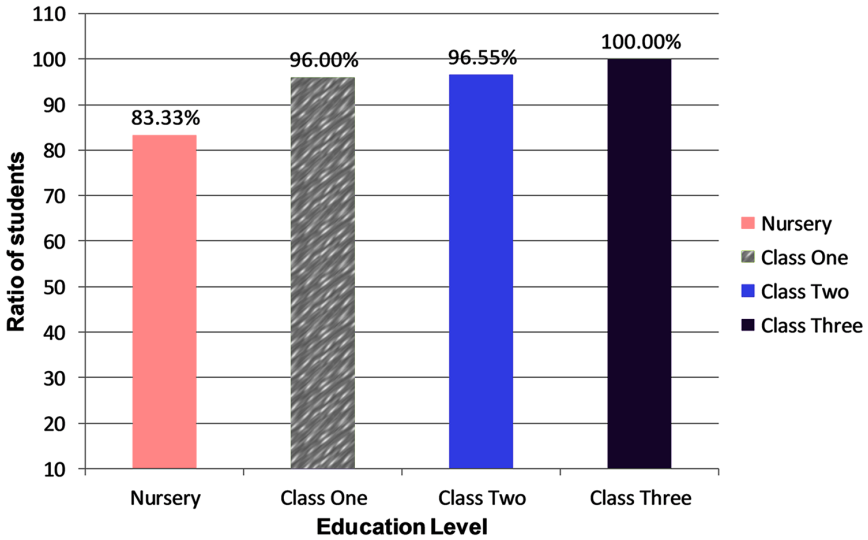
Table 3. Time taken for completing task no. 2

Task #2	Nursery	Class One	Class Two	Class Three
Time taken (Seconds)	20-25	15-18	12-15	8-10

Table 4. Comparison of task no. 1 and task no. 2

Task #	Nursery	Class One	Class Two	Class Three
Task 1(%)	64.44%	85.33%	91.38%	93.48%
Task 2(%)	83.33%	96.00%	96.55%	100%

Figure 11. Ratio of students completing task no. 2



the task no. 1. The user interface of application with finger swipe was user friendly and easy to use as compared to user interface of application with separate graphical buttons. In this task each activity contained an audio sound; visual image and text of particular letter of Sindhi alphabet letter. It was also observed that students of all levels were enjoying much more with finger swipe. They were exited to perform the activities with their finger swipe.

Task #3: To find out the English Alphabet letter "F" with Button Click.

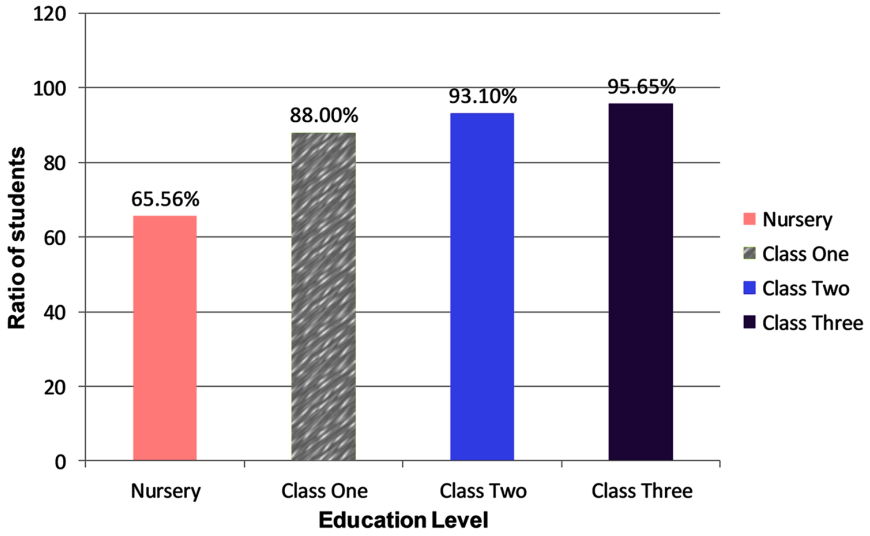
Figure 12 shows the task no. 3 performed by students of nursery, class one, two and three level.

Data in Figure 13 shows the ratio of students who completed the task no. 3. In this task each activity consisted of English alphabet letter in upper as well as lower case, its pronunciation word in Sindhi language, an audio sound for particular letter and graphical buttons for next and previous activities.

As the data in above figure shows 95.65% of students of class three, 93.10% of students of class two, 88.00% of students of class one and 65.56% of students of nursery class completed the task no. 3 easily. The user interface of task no. 1 and task no. 3 was similar, as both interfaces were based on graphical buttons. The ratio of students performing task no. 3 was little bit higher than the ratio of students performing the task no. 1 with button click. After performing the task no. 1 students became familiar with graphical buttons,

Figure 12. Task no. 3

Figure 13. Ratio of students completing task no. 3



so they were feeling less hesitation to click the button for next or previous activity. It was observed that students were feeling less hesitation when same activity was repeated. Table 5 shows the time taken by students to complete the task no. 3.

The user interface of task no. 3 was based on graphical buttons, so students of nursery and class one were taking more time to complete the task as compared to students of class two and three. It was observed that students of nursery and class one were feeling hesitation to click at the button for next or previous activity.

Task #4: To find out the "3" in counting with Button Click.

Figure 14 shows the task no. 4 performed by students of nursery, class one, two and three level.

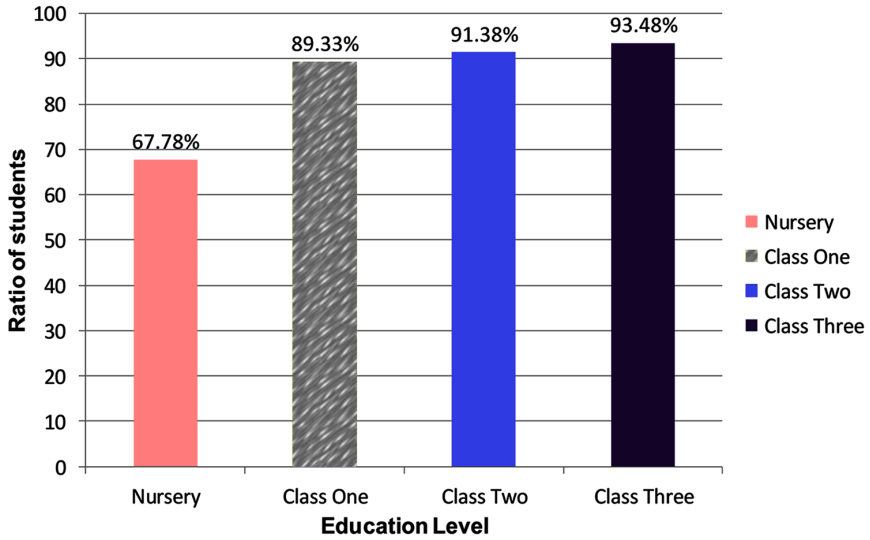
Data in Figure 15 shows the ratio of students who completed the task no. 4. This activity was based on number counting from 0 to 10. In this activity the user interface consisted of visual images, audio sound, Sindhi and Roman numbers, their pronunciations in Sindhi and English language and graphical buttons.

Table 5. Time taken for completing task no. 3

Task #2	Nursery	Class One	Class Two	Class Three
Time taken (Seconds)	32-36	25-30	15-18	10-12

Figure 14. Task no. 4

Figure 15. Ratio of students completing task no. 4



As the data in above figure shows 93.48% of students of class three, 91.38% of students of class two, 89.33% of students of class one and 67.78% of students of nursery class completed the task no. 4 easily. Students became more familiar about the user interface of the application, so they were excited and took less time to complete the task. Table 6 shows the time taken by students to complete the task no. 4.

The user interface of task no. 4 was based on graphical buttons, but students of all classes were familiar about the interface after completing the task no. 1 and task n0. 3, so they were not feeling much hesitation to complete the task.

4.2.1 Post-Test Questionnaires

After completing the practical tasks by students, following questions were asked as post-test questionnaires:

Table 6. Time taken for completing task no. 4

Task #2	Nursery	Class One	Class Two	Class Three
Time taken (Seconds)	20-25	12-16	10-12	6-8

1. Have you enjoyed the lessons using Tablet PC?
2. Would you like to use this application on Tablet PC in your class?
3. Would you like to use this application on Tablet PC at your home?
4. Is audio sound helpful or not?
5. Are visual aids helpful or not?

Post-test questionnaires were asked from students of all sample classes after the usability tests in order to know the suggestions, opinions as well as feedback. The feedback of students was recorded by the researcher. The questions were designed with "Yes" or "No" options. 84% of students had positive feedback for implementation of this application at their schools, however only 16% of students had given negative responses for the implementation of this application using Tablet PC at their schools. Table 7 shows the post-test questionnaires responses of each class after the usability tests.

Following figures shows the summative results of each post-test questionnaire separately.

Table 7. Post-test questionnaires responses

Question	Nursery	Class One	Class Two	Class Three
1. Have you enjoyed the lessons using Tablet PC?				
a. Yes	81%	83%	87%	91%
b. No	19%	17%	13%	09%
2. Would you like to use this application on Tablet PC in your class?				
a. Yes	75%	80%	83%	82%
b. No	25%	20%	17%	18%
3. Would you like to use this application on Tablet PC at your home?				
a. Yes	77%	81%	77%	81%
b. No	23%	19%	23%	19%
4. Is audio sound helpful or not?				
a. Yes	84%	87%	89%	90%
b. No	16%	13%	11%	10%
5. Are visual aids helpful or not?				
a. Yes	85%	88%	90%	92%
b. No	15%	12%	10%	08%

1. Have you enjoyed the lessons using Tablet PC?

Data in Figure 16 shows the response of students. Only 14.50% of students had negative response; however 85.50% of students had positive response that they had enjoyed the lessons using Tablet PC.

2. Would you like to use this application on Tablet PC in your class?

Data in Figure 17 shows the ratio of students who were willing to use Tablet PC in their classes. 20.07% of students had negative response; however 79.93% of students had positive response regarding the use of Tablet PC in class rooms.

3. Would you like to use this application on Tablet PC at your home?

Data in Figure 18 shows the ratio of students who were willing to use Tablet PC at their homes. 21.93% of students had negative response; however 78.07% of students had positive response regarding the use of Tablet PC at their homes.

4. Is audio sound helpful or not?

Data in Figure 19 shows the ratio of students who were supporting the use of audio in developed application. 12.64% of students had negative response; however 87.36% of students had positive response regarding the use of audio sound in the application.

Figure 16. Ratio of students enjoyed using Tablet PC

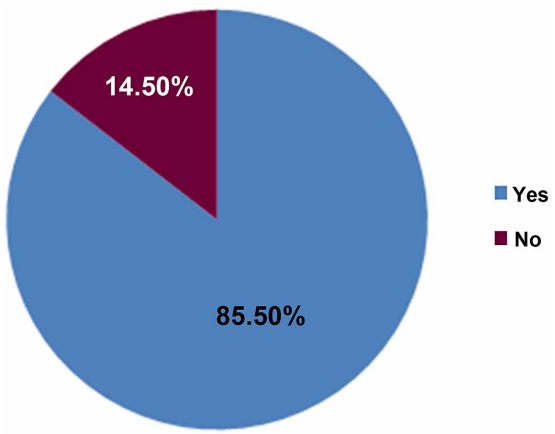


Figure 17. Ratio of students willing to use Tablet PC in their classes

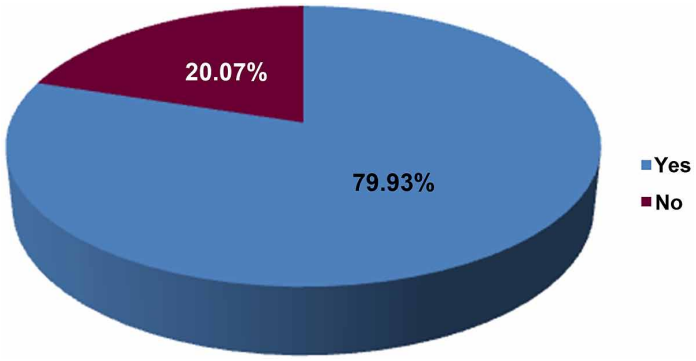


Figure 18. Ratio of students willing to use Tablet PC at their homes

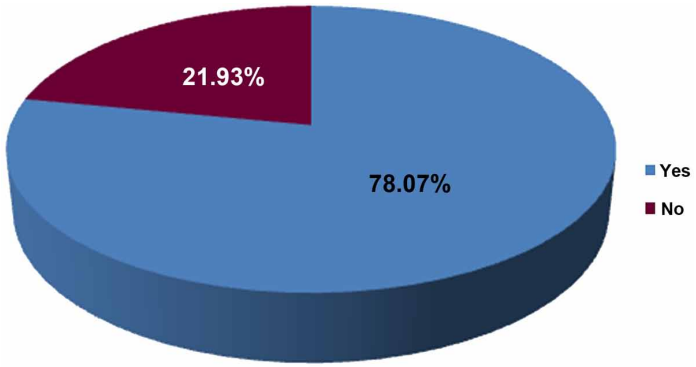
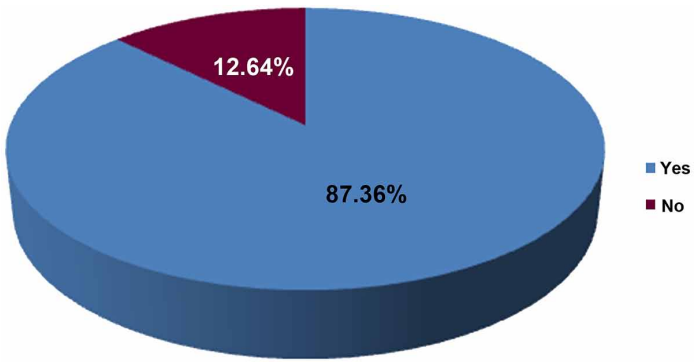


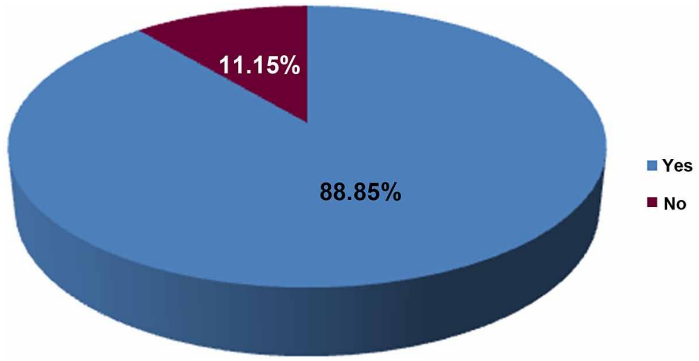
Figure 19. Ratio of students supporting audio sound



5. Are visual aids helpful or not?

Data in Figure 20 shows the ratio of students who were supporting the use of visual aids in application. 11.15% of students had negative response; however 88.85% of students had positive response regarding the use of visual images in the application.

Figure 20. Ratio of students supporting visual aids



4.3 Teachers' Perceptions

The usability tests were also conducted by the teachers who were teaching to students of nursery, class one, two and three in order to get their suggestions, opinions and feedback. It is suggested that if the teacher has good ICT skills, then the effectiveness of ICT in teaching and learning is improved. Those teachers who have lack of knowledge of ICT have shown negative results towards its implementation in teaching (Hew & Brush, 2007).

A total of 22 teachers participated in usability tests. Figure 21 shows the number of teachers who were teaching in the classes of nursery, one, two and three.

Data in Figure 21 shows the number of teachers who participated for usability tests. 55% of teachers had 12 to 15 years teaching experience, 20% of teachers had 7 to 11 years teaching experience and 25% of teachers had 3 to 6 years teaching experience. Up to 60% of teachers were aware about the usage of computers and touch screen devices, which suggested that remaining 40% of teachers need proper ICT training.

Data in Figure 22 shows the teachers' perception regarding the improvement of quality of learning by implementing Tablet PC in education.

Figure 21. No. of teachers

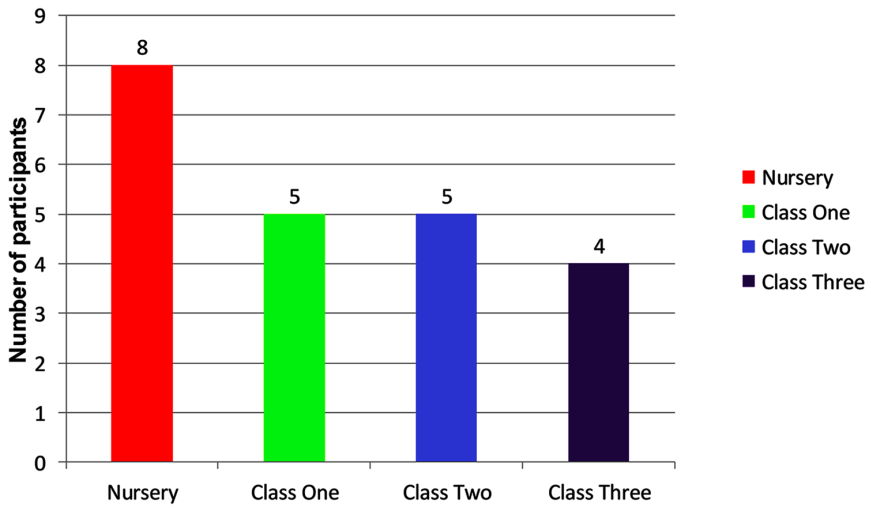
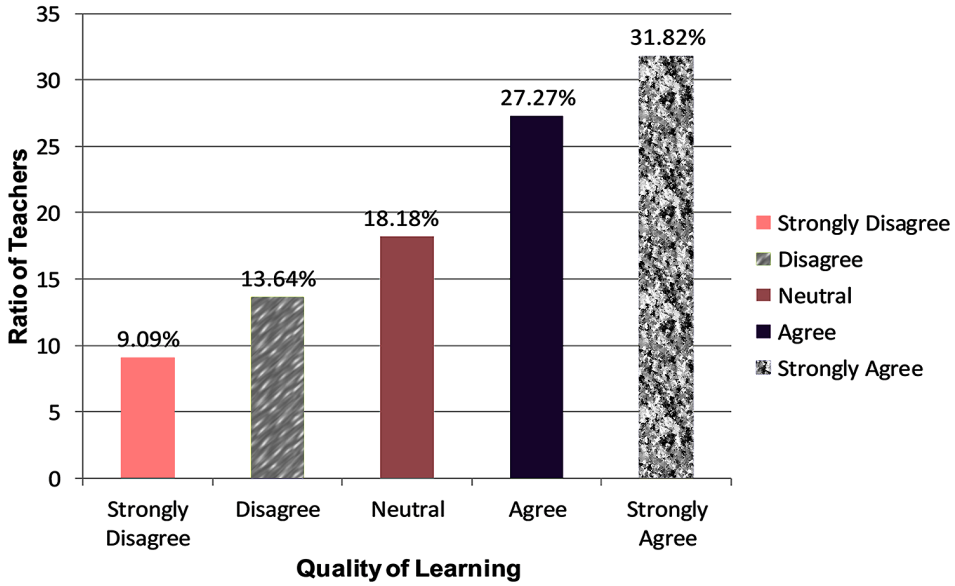
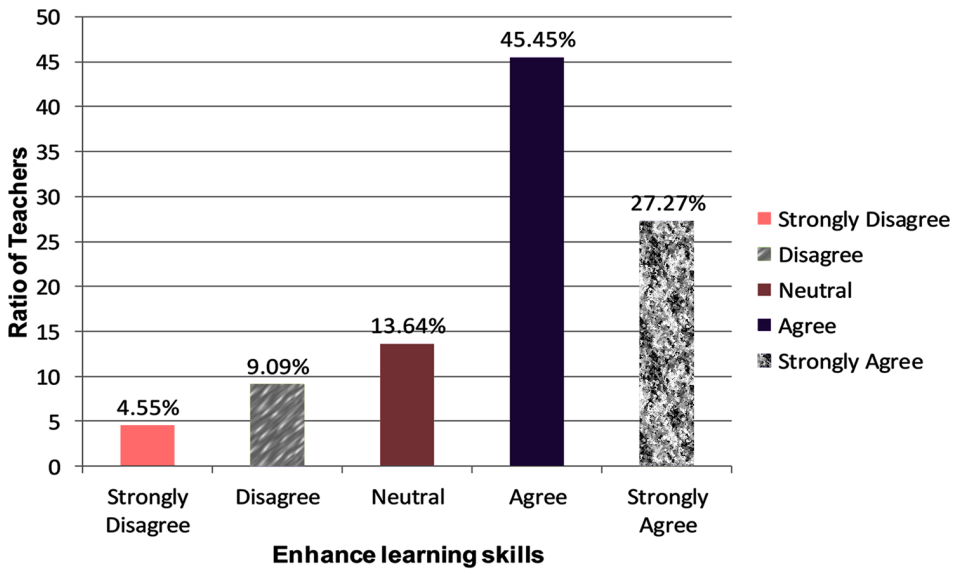


Figure 22. Teachers' perception regarding quality of learning



As the data in above figure shows that 31.82% of teachers' response was strongly agree, 27.27% of teachers' response was agree, 18.18% of teachers were neutral in their response, 13.64% of teachers' response was disagree and 9.09% of teachers' response was strongly disagree. The overall result of Figure 22 shows that 59% of teachers had positive response, however only 23% of teachers had negative response regarding the usage of Tablet PC for the improvement of the quality of learning. Data in Figure 23 shows the teachers' perception regarding the improvement of students' learning skills using Tablet PC in classrooms.

Figure 23. Teachers' perception regarding students' learning skills



As the data in above figure shows that 27.27% of teachers' response was strongly agree, 45.45% of teachers' response was agree, 13.64% of teachers were neutral in their response, 9.09% of teachers' response was disagree and 4.55% of teachers' response was strongly disagree. Overall results of Figure 23 shows that 73% of teaches had positive response, however only 14% of teachers had negative response regarding the usage of Tablet PC in order to improve the learning skills of students.

Using Tablet PC each student becomes self-directed and self-motivated learner. Students can be able to learn the lessons in a group, so student-student interaction is increased. Figure 24 shows the perception of teachers regarding the use of Tablet PC in order to improve the student-student interaction and group collaboration.

As the data in above figure shows that 36.36% of teachers' response was strongly agree, 31.82% of teachers' response was agree, 9.09% of teachers were neutral in their response, 13.64% of teachers' response was disagree and 9.09% of teachers' response was strongly disagree. Overall results of Figure 24 shows that 68% of teaches had positive response, however only 23% of teachers had negative response for use of Tablet PC in order to improve student-student interaction and group collaboration.

In primary schools more than one class are assigned to a single teacher with multiple enrollments of students. A single teacher cannot utilize his / her time properly for each of the student. With the implementation of Tablet PC each student is able to learn without much involvement of teacher, so teacher time can be utilized in a better way. Figure 25 shows the perception of teachers regarding the better utilization of teacher time using Tablet PC.

As the data in above figure shows that 36.36% of teachers' response was strongly agree, 40.91% of teachers' response was agree, 4.55% of teachers were neutral in their response, 9.09% of teachers' response was disagree and 9.09% of teachers' response was strongly disagree. Overall results of Figure 25 shows that 77% of teaches had positive response, however only 18% of teachers had negative response for use of Tablet PC in order to utilize the time of teacher properly.

In private schools of district Shaheed Benazirabad, Sindhi language is taught at class level two and three. However in public schools of same district, Sindhi language is taught at nursery level. In private schools of this district, the medium of

Figure 24. Teachers' perception regarding student-student interaction

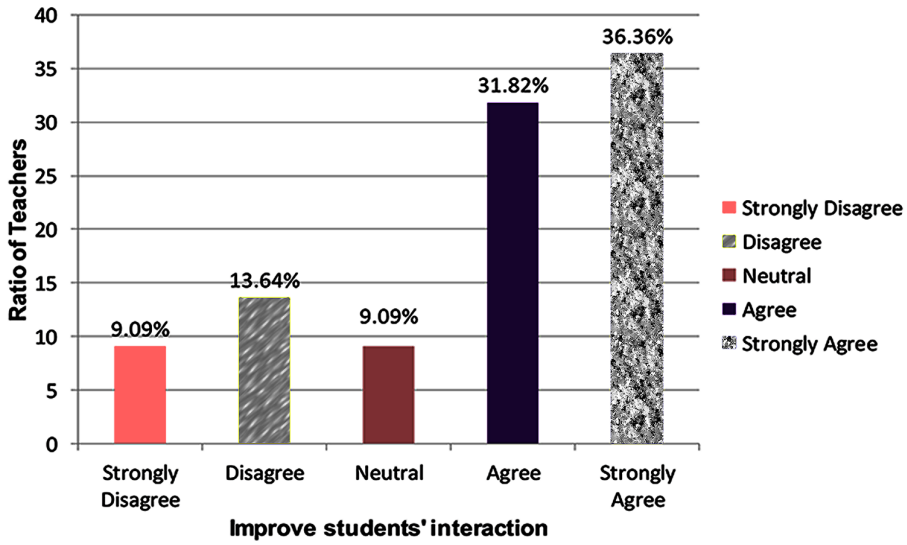
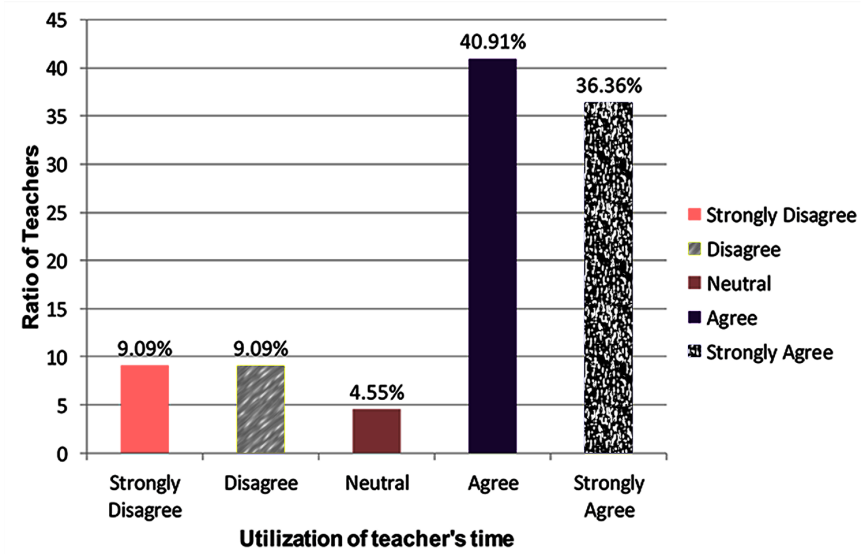


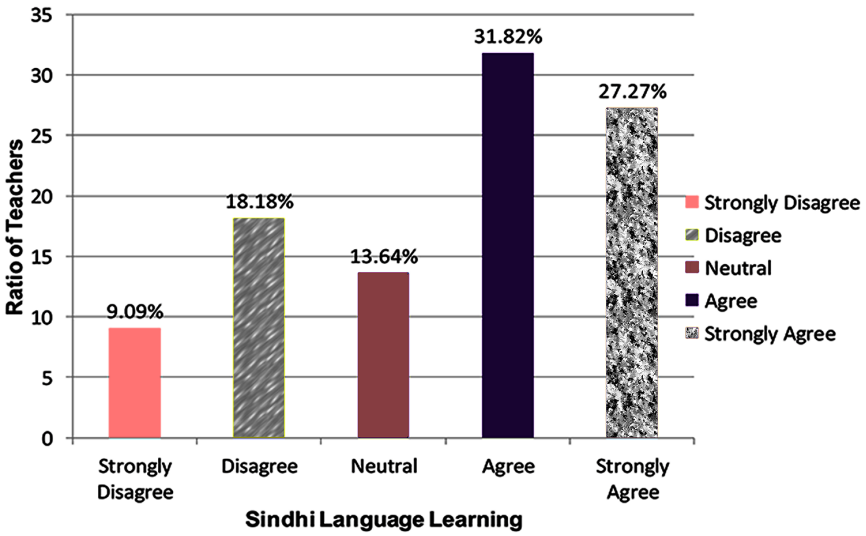
Figure 25. Teachers' perception regarding utilization of teachers' time



teaching is either in English or Urdu, so this application would facilitate the learning of Sindhi language to those students whose mother tongue is not Sindhi. Figure 26 shows the teachers' perception regarding the learning of Sindhi language using Tablet PC.

As the data in above figure shows that 27.27% of teachers' response was strongly agree, 31.82% of teachers' response was agree, 13.64% of teachers were neutral in their response, 18.18% of teachers' response was disagree and 9.09% of teachers' response was strongly disagree. Overall results of Figure 26 shows that 59% of teaches had positive response, however only 27% of teachers had negative response for use of Tablet PC in order to learn the Sindhi language.

Figure 26. Teachers' perception regarding learning of Sindhi language



Tablet PC can be an effective teaching tool, which would facilitate students to learn the lessons easily. Figure 27 shows the cumulative result of perception of teachers regarding the effectiveness of Tablet PC as a teaching tool.

As the data in Figure 27 shows that 77.27% of teachers had positive response and 22.73% of teaches had negative response regarding the effectiveness of Tablet PC as a teaching tool.

The atmosphere and infrastructure of private schools were better as compared to public schools, so interactive learning systems using Tablet PC can be implemented in private schools in a better way. Data in Figure 28 shows the cumulative result of teachers' perception regarding the implementation of Tablet PC in their schools.

As the data in above figure shows that 63.64% of teachers had positive response and 36.36% of teaches had negative response regarding the use of Tablet PC at their schools

5. CONCLUSION

Tablet Computers and other smart devices are becoming familiar from nursery level to university due to their portable nature. This shows that the technology-oriented tools facilitate the learning outside the traditional classrooms, anywhere and anytime (Wong, L.-H, 2012; van 't Hooft.M, 2013). In this research an application were introduced and tested at five primary schools of district Shaheed Benazirabad, Sindh. The usability tests were conducted from both the teachers and students. The attention of students towards the technology-oriented lessons was enhanced and they were found to be active during the usability tests. After usability tests it was observed that students understood the lessons in easier and better way. With Tablet PC, each student became a self-directed learner which made the student busy and hence increased his/her interest for the

Figure 27. Tablet PC as an effective teaching tool

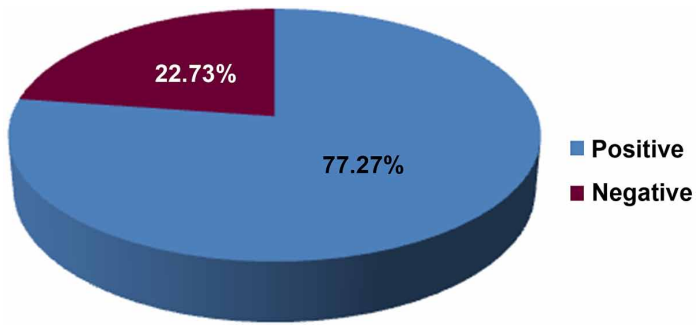
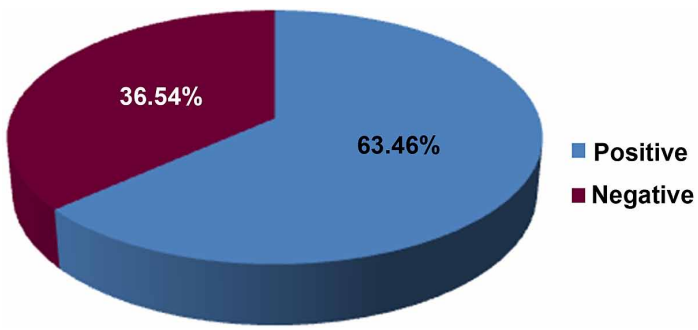


Figure 28. Tablet PC implementation at schools (teachers' response)



learning. So Tablet PC can be used to increase the interest of students towards the learning. Teachers' attitude towards the implementation of Tablet PC was quite positive and they suggested that these applications would be helpful in order to improve the learning skills of students. This research has also focused on the analysis of effective use of technology and its impact on the attention, attitude and understanding of students in the primary education through usability tests. Questionnaires from the teachers and students have also been conducted which have shown positive results towards the implementation of ICT tools in the primary education. Overall, students and teachers have had quite positive feedback for implementing the Tablet PC technology in primary education. This shows that the Tablet PC is an effective means of teaching that provides an active learning environment.

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KEY TERMS AND DEFINITIONS

Interactive Learning: A learning where users receive the feedback at real time from a device.

Primary Education: An elementary education provided at the first stage to the students when they are enrolled in schools.

Self-Directed Learning: A process where individuals take initiative in order to increase their knowledge or skills at any time and place without the help of teacher.

Sindhi Language: The second largest language spoken in Pakistan and various other states of India. It consists of 52 alphabet characters taken from Perso-Arabic script.

Tablet PC: A portable device with user friendly touch screen interface operated with finger or stylus pen.

Usability Test: The technique to test how easy a user interface is. It is conducted with real users who will use the product.

User Interface Design: The design of software applications or hardware interfaces with which the users will interact. Purpose of the user interface design is to create the applications interfaces user friendly.

Chapter 21
Learning Goes Mobile:
Devices and APPS for the Practice of Contents at Tertiary Level

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ABSTRACT

Nowadays, mobile learning allows the use of mobile devices in teaching and learning practices of almost any subject or topic of interest. In this chapter, we describe a research carried out to get data about the use that university students make of mobile devices and apps for learning purposes, as most of them use mobile phones and tablets as communication and entertainment tools, but don't get benefit from these devices as educational resources, either due to lack of knowledge or to the scarce information about the pedagogical uses of these devices. The methodology followed is based on an analysis of the results obtained from questionnaires implemented to students. From the data collected, we draw a number of conclusions relevant not only to the successful development research studies like this, but also for the implementation of teaching initiatives including mobile devices and applications for improving learning processes in general.

1. INTRODUCTION

Our society is nowadays suffering important changes at all levels, which are, to a great extent, affecting our lives and, especially, our way to learn and communicate. The vast quantity of information together with the high influence of the mass media at a global scale is generating substantial transformations that range from changes in global paradigms at a social, economic and cultural order, to new habits in our everyday life, voiced through the way we dress, act, and even through how we interact and relate with others. The youth of today, Digital Natives, have grown up with the Internet and social media. This new generation has radically changed, they live most of their lives online

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and have a tendency to multitask and express themselves by creating new in-formation and art forms (Prensky 2001; Palfrey & Gasser 2008).

In the last decades, the use of mobile devices has suffered a notable increase in all areas of human life, assuming a more and more relevant role in society and generating a dominant need for people, teaching-learning, formation and training processes carried out throughout our lives, and which are so necessary for the correct development, acquisition and application of personal, familiar, social, academic, professional, economical and cultural competences. As Katz (2008) explains it: "there are some remarkably consistent changes in personal routines and social organization as a result of literally putting mobile communication resources into the hands of people" (p. 3).

As Katz, Lever and Yi-Fan (2008) put it, although they were formerly technologies of personal isolation, mobile devices seem destined to be expanded into technologies of conviviality, and thus these new media technologies have made physical boundaries more permeable and have also transgressed the boundaries of private and public life (Meyrowitz 1985; Morley 2000; Nikunen 2010).

Teaching has always been bound together with information transmission processes, as well as with the mere reception of knowledge, as if it was a simple process, forgetting that the learning process entails bearing in mind the different dimensions that make it possible. According to Fernández Huerta (1985) those dimensions are: a human being who teaches, a human being who is taught (addressee of the learning process), an object being taught (content or object about which something is taught), a mediator in the learning process (a resource, methodology or procedure through which the content is taught), a teaching act (actions in the process), and all this, as Fernandez stated (1986, 1996), outside the real context where it happens.

The mere transmission of knowledge, by itself, acquires a unilateral value that lacks sense if it is not accompanied by another essential process to be effective, which is learning.

The learning process depends, to a great extent, on the human behavior and thought, as it aims to reach an integral development of the human being taking into account his needs and the social convictions around him (Zabalza, 1987). To attain this task requires order, structuring, and perfection of mental and personal functions (cognitive, behavioral and attitudinal. That is to say, instruction and formation. The instruction seeks for, through personal, group, institutional and instrumental acts, the optimization and perfecting of both the person and the action being carried out (e.g. learning a foreign language). This process is not supported in vacuum, but it looks for an external bracket that acts as backing and provides equilibrium, which in this case is information, preceded by a perfective intentionality and a search for a constant improvement and update.

Teaching, learning, training and instruction are elements of the teaching act that have been part of traditional education and should continue to do so in education today, since many of the educational activities are being implemented in virtual and electronic environments where new generations of learners learn by performing (learning by doing), working (Echeverría, 2012), creating, consulting, using, and sharing information and knowledge at all times and in all places (ubiquitous learning), since society raises today new needs that must be addressed and resolved.

This *e-space* to which the authors are referring, could be said to be a systemic space, in which the various components that constitute or variables interact, and where they are conditioned and modified (Canton & Pino-Juste, 2014) through activities and services that are developed on it. Something that we have to take into account at this point is that mobile devices are seldom used

as isolated technologies. As Katz (2008) states, they do not exist in isolation, but in relation to technologies such as the landline phone, physical cable infrastructure, and the Internet. The mobile device is a multipurpose tool, the uses of which extend far beyond mere text or voice communication. It has become a music platform, calendar, watch, alarm clock, calculator, and game player. It is also a PC terminal for interacting with the Web and Internet (p. 10).

Additionally, this e-space, takes full effect in its holistic and integrative dimension, and must be applied in a practical context where all the theoretical components (knowledge), artistic (personal and vocational skills) and technological ones are properly planned as activities (thought out and practical applications reasoned, 'know-how') which take action and promote the achievement of adequate praxis.

The continued widespread use of mobile devices in all sectors and areas of life in general and of the society in particular, have an increasingly dominant role in the daily work, which is considering the need to incorporate them into teaching and learning to provide them with a consolidated structure whose use has become commonplace as has happened with virtual and electronic spaces. These e-spaces, in the words of Javier Echeverría (2012), "made possible the emergence of a new social space, space or electronic digital world" (p. 42), which seeks to approach and represent the underlying reality and orient it towards a stimulating practice that promotes trans-disciplinary forms of work (Cieza, 2009; Arnold, 1989) to generate the development of emerging disciplines with their own conceptual framework.

Mobile devices like smartphones, tablets, notebooks and laptops, are developing new forms of knowledge that are transforming the information, communication, relationships and the individual, collective and institutional human actions that increasingly occur multichronically (one event or occurrence may be repeated repeatedly in the digital world, and can even be programmed in a few other times and in other no) in a remote network (Echeverría, 2012, p. 42) and whose reality is constructed in each specific context in which it occurs, only being the interpretative and understanding function what guides their practical judgment (Carr & Kemmis, 1986). The understanding and interpretation of the e-spaces inexcusably gets through the value and meaning that users give to the reality in which they move and its activities, since teaching and learning are always a permanent and changeable meaning building process, modifiable and adaptable, that will allow preserving, innovating, producing or recreating them in regards to the historical, geographical, and cultural moment in which they occur.

Living and learning in the network society (Castells, 1999) will result in gradual and regular daily use of mobile devices and digital and virtual spaces in education in general, and in architecture studies, in particular, becoming new areas in which knowledge is created and shared, both interdisciplinary and multidisciplinary. Achieving this goal involves having this in mind and act accordingly with which is undoubtedly one of the most important aspects for the use of mobile technologies and their true effectiveness, which is the personalization of the mobile phone, seen as part of the life and private space of the user, requiring absolute respect the use that the individual wants to make of it. A mobile belongs to the individual who owns it, and only he can decide when, where and the amount of time s/he wants to use it. Not respecting this matter involves interfering in the life of the person, beyond the limits of their trust and, therefore, breaking the balance and freedom that makes it possible to become a large-scale educational act.

2. BACKGROUND

Nowadays, the possibilities of communication have exponentially grown thanks to the popularity of devices that, despite its obvious and playful

communicative function, also have an important facet of educational achievement. In this regard, Smartphones, tablets and notebooks have become everyday items with which the user often fills in time between teaching spaces or activities. Are these time slots, on the way home or between classes, which can be exploited as practice times to enhance competition in certain knowledge, using applications (*Apps*) and other tools that allow users to deepen the content treated in the classroom or practice skills comfortably following learning known as ubiquitous learning (*u-learning*).

Without a doubt, mobile devices, applied to specific fields such as engineering, architecture and other disciplines that belong to them; allowing access to information, streamline processes and facilitate learning in a different and innovative way (García & Iglesias, 2014; Iglesias & García, 2014) and which have a positive impact on the academic performance of students. Educational institutions are no longer the only place in which information is managed and in which the information and communication technologies (ICTs) are used. On the contrary, it is in informal spaces where mobile devices are used with a greater degree of creativity, diversity, motivation and involvement (Lankshear & Knobel, 2003, 2006), with the insider generations (digital natives) responsible to make it effective.

Taking advantage of all the possibilities offered by mobile devices involves making changes in teaching and learning processes (Lankshear & Knobel, 2003; Angulo, 2004; Sefton-Green, 1998, 2004; Kress, 2003) such as these:

1. Accessibility to the network increased and, therefore, the ability to learn and acquire knowledge anywhere and anytime;
2. New virtual spaces in which a person can "move" and acquire information displayed;
3. The ad hoc and informal learning increases and takes a prominent place in contexts outside the classical education;
4. Increase in the amount of networks and practical learning communities of all kinds;
5. Daily life and online life are part of the same continuum and live inextricably connected;
6. Teaching and learning take on a flexible role in virtual mobile scenarios since the subject can take both the role of 'teacher' as the role of 'learner', based on the best knowledge and context of interaction which is produced;
7. The subject no longer accesses the network with the sole purpose of obtaining information, but also to produce it, reorganizing existing one or creating a new one that will be shared in the 'cloud' on the Internet;
8. The management of information is multimodal (sound, images, texts, hyperlinks, etc.), which places the individual in a post-typographic knowledge context;
9. Breaks with the linear-typographic structure of traditional texts, giving way to structure information in hypertext and hypermedia digital environments;
10. The boundary between work and play is diluted whenever the organization, recreation of information and the effort and time it takes to do it, entertains them, amuses them and poses a challenge for them;
11. The insiders conduct, in a certain way, an active and creative management of the copy; transform but reproduce and modify the original (changing colors, links, fonts, etc.), intertwine and juxtapose the texts according to their interests and use the information available on the network;
12. The digital natives have a sharp and strong sense of activity (performance). Do not refer in their "digital" practices to the software they employ, but the work they do, that is to say, "do things" but do not use any software (Angulo & Vázquez, 2010).

Unlike the Internet, mobile devices favor the solution of different problems and situations in

'real time' by offering the possibility of adaptation and response fitting to the demands, needs and individuality of the wearer. The usability of these devices and the motivation generated by those who use them are determined by the values that accompany them, such as interactivity (based on the feedback and feedforward that the subject needs in the moment when it is required), convenience (access to the application by the user at the right time), location (clear indicator of where the user prefers to receive the message) and the speed and adaptability (in time and format).

At first, it may seem that mobile devices do not allow interaction between members who are part of the virtual learning communities; however, it is precisely this conception of community that facilitates and organizes dialogue, communication, negotiation, collaboration, sharing ideas and solving problems that arise throughout the educational process performed, thereby eliminating barriers to learning presence that even the technologies can cause, leading to the 'digital division. Working in a shared way rejects any kind of educational exclusion, encourages participation and cooperative learning, enables building inclusive environments, increased personal security, encourages shared leadership and distributes the responsibility of the participants. This new concept of community of mobile learning developed in e-spaces, invites its users to change, explore, design and present new learning options adapted to permanent technological changes to which we are subject in modern societies, while they open our mind towards establishing an eclectic education paradigm oriented towards a process of personal construction by the insider, whose role is primarily to build and assimilate new knowledge and meanings, changing and rearranging his/her prior knowledge.

This type of mobile learning, only makes sense if the technology used is truly 'mobile' and if the same users also act in a 'mobile' way while learning (El-Hussein & Cronje, 2010, p. 14); understanding as 'mobile' the capabilities and possibilities of the technologies within the e-spaces and activities that users perform as they participate in the many interactive and multidisciplinary proposals offered.

In short, mobile learning favors, under the very conception of the authors of the chapter, creating processes that allow us to study, develop and substantiate the necessary actions to adequately perform effective teaching and learning strategies usefully incorporated into actions over a society that is constantly changing.

Achieving this purpose requires a comprehensive and thoughtful effort by education professionals in the field of architecture, who are primarily responsible for creating and developing theoretical and applied models for a better interpretation of this complex discipline, as well as of the expectations, interests and motivations of students towards it. Without doubt, the effort derived from this action involves a partnership between professionals and students in order to conduct a proper process of teaching by the former, which will be translate into learning to do and learning to learn how we learn, for the students to get the most out of the learning processes provided by the ubiquitous learning.

As shown, mobile learning encourages to open e-spaces to unimaginable contexts (graphic architectural design, modeling and representing, usability, accessibility, urban and architectonic planning, building, etc.) taking into account the reality of each person and the changing situations permanently displayed in the current evolving and pluralistic society. But not to achieve an adaptation to different situations, but to use them to generate new learning situations shared by all insiders who are part of the virtual learning community of teachers and students, so that they can live, internalize and incorporate the process' analysis and the results thereof to the development of their personality.

It is, in short, to seek and find new ways to solve these problems through the contributions of emerging scientific disciplines such as neurodidactics (in the educational field) and neuroar-

chitecture (in the professional field), whose role is to study the optimization of learning based on brain development (Iglesias, 2008) or what is the same, learn all the brain power and be able to move to virtual environments where auditory applications, images, texts, videos, movements, light, space management, etc., fit perfectly to the preferred embodiment through which each person has to receive and feel information through their senses (visual, auditory and kinesthetic), because not everybody learns the same way or at the same speed, the same way that not everybody is pleased with the arrangement of physical spaces, the environment in which they are distributed, etc, which cause different impacts on physical and emotional health, as every detail depends on the design of the places is adjusted to the desires of the different users that could access them. Each individual has a series of personal, physical, psychological and social characteristics that differentiate them from the rest; and these differences provide various forms of human acting, deciding and learning.

From an educational point of view, each person learns according to the learning styles and teaching strategies used; that is, according to the strategies or methods used by each subject at different times to carry out their learning. And this is where ubiquitous learning and mobile learning gain a great sense, as there are many diverse personalities accessing these e-spaces, requiring the teacher to possess different activities to reach the predominant type of personality, considering that the optimum conditions in which you can run the brain of a person are related to the movement, water, music and the visual environment. Therefore, the level of cognitive stimulation that students are offered, will reflect the type of learner that you want to teach.

From this perspective, mobile technologies, foster creativity and facilitate the adequacy of the design of physical environments in which people have to unwrap the emotional states and behaviors of individuals who use them, considering that "set design can promote or facilitate a particular behavior in terms of how they perceive individuals who frequent it, which in turn depends on the socio-demographic and / or characteristics thereof (beliefs) "(Subtle & Perán, 2012, pp. 2-3)

Implementing all these issues that have been addressed so far in this chapter, requires to bear in mind different theories and models which provide the conceptual framework on which they are based, as they help better understanding certain behaviors that can arise in the use of technology mobiles, how those behaviors relate to the way insiders learn and the type of actions that could be undertaken to achieve effective results in specific virtual situations.

As Amparo Fernández March (2010) says

… the subject needs to be able to manipulate the knowledge, update it, select what is appropriate for a specific context, to permanently learn, to understand what is learned and all so that it can adapt to new situations that will rapidly transform. (p. 15)

2.1. Founding Theories, Approaches, and Models of Mobile Learning

As above mentioned, mobile technology is characterized by its ubiquity. This means that any user has unregulated, uninterrupted access to technology and the use they can make of them is varied: from access to educational content, to share information, discuss with others, ask for help from colleagues, friends, teachers; to facilitate a more productive communication.

In this respect, Traxler (2007, pp. 1-13) writes "so, mobile learning is not about 'mobile' or about 'learning' as previously understood, but part of a new mobile conception of society".

Traxler (2007) and others advocate to define mobile learning as wireless and digital devices and technologies, generally produced for the public, used by a learner as he or she participates

in higher education. Others define and conceptualize mobile learning by placing a strong emphasis on the mobility of learners and the mobility of learning, and the experiences of learners as they learn by means of mobile devices (El-Hussein & Cronje, 2010, p. 14).

Mobile devices favor a largely personalized learning of its members, as they are not only owners, but it usually is a device they carry with them all day, manipulate it, play with it, use their applications and hence suit their individual needs, hence being more flexible and adapting to their own learning pace; which in many cases leads to increased motivation and thus, a greater opportunity to manage their learning (Garcia & Iglesias, 2014; Iglesias & Garcia, 2014).

In learning processes, there are three main influential factors (Spitzer, 2005): attention, emotion and motivation. To learn something, it is necessary that the mind of the subject is awake. This means that to get students to pay attention to the information you want, you need mobile devices to give and take relevant stimuli that activate just those neural structures available for the processing of such information or task.

When a person is watching, it does not only produce a psychological process, but also a neurobiological process. That is to say, more strongly activate those areas which are relevant to the processing aspects of the virtual environment and objects to which the individual draws attention and, therefore, make him/her able to retain the information. Learning only appears when neurons are activated.

From an educational point of view, you can only draw attention to what should be learned when a real effort takes place, when there exist the appropriate emotions, and when the subject is motivated to perceive things and examine them in detail.

Emotions, in turn, play an important role in learning and having a cognitive, qualitative and physical component. Acute emotional arousal may improve retention of certain events in the memory; but it really encourages people, not the data and facts but feelings, stories and communication, interaction and relationship with others.

As to the third factor influencing learning: motivation, the authors have to say that although our brain is an expert in learning, every second it receives countless stimuli that can make us get blocked. To appropriately react to many stimuli, we must have precise filtration and control processes in order to select and process only the information that we consider important. Motivation is the force that moves a person to perform certain actions and / or activities and persist in them for completion. A person is motivated when s/he does something and is also able to continue the effort that something requires in time to follow the goal that has been set.

These actions put by the subject into practice, become the best way to predict and explain his/her behavior and the impact of hi/her behavior on the subject itself and the group with which he/she interacts (Theory of Planned Behavior), which would help explain, firstly, to what extent the individual accepts the innovations associated with the use of technology (Azjen, 1985), and, secondly, what is the perceived usefulness depending on the results and on the consequences of the actions carried out, together with perceived degree of effort involved in managing a particular mobile device (Model -Tam- Aceptation Technology) (Davis, 1989; Venkatesh & Davis, 2000).

The complexity of the process, has led to an attempt to unify criteria to further explain the variables that are necessary to take them into account for innovative proposals made in education, in fields such as architecture, and accepted by those who make use of technological innovations. This has been possible thanks to the model proposed by Verikatesh, Morris, Davis and Davis (2003) called the Unified Theory of Acceptance and Use

of Tecnhology (UTAUT), which focuses on four variables: expectation of outcome, effort expectation, social influence and facilitating conditions.

The expected result, in the present case, would be the extent to which the student-user perceives that the use of mobile learning will improve their academic and professional performance (extrinsic motivation, perceived usefulness, etc.). Meanwhile, the expectation of effort is related to the student's perception about the ease of use of mobile learning, regardless of where you are. Additionally, social influence has to do with the extent to which the student-user considers important and is influenced by the opinions of people who are meaningful to him, as to whether s/he should not use this type of training modality. And finally, the enabling conditions (Facilitating conditions) focus on the extent to which the student-user perceives that the organizational techniques and the educational conditions which are necessary to support this technological innovation exist in his/her academic context. Along with these variables, the UTAUT model identifies four others related to the specific characteristics of each subject: age, gender, experience and voluntariness of use (Martín García, 2014, pp. 69-70).

All these aspects the authors have been alluding to, are not produced in a short space of time since there are concrete actions that take place at a certain time and in a context prepared in advance, but it's rather a process that happens over time and is conditioned by one's perceptions and beliefs of the subject (ideas, opinions, information, stereotypes, fashions, acceptance of the majority group) and by previous experience in the academic, professional and social system (personal habits, routines, values of the reference group, context, personality, and socio-demographic characteristics) where the individual belongs to.

Therefore, it could be inferred that the adoption and acceptance of mobile learning by students in the academic environment of architecture studies is conditioned, among other things; by perceptions that students have about this type of educational innovations, the whether its employment impact in improving the learning process is positive and, therefore, in its results; by the program's compatibility with the values, experiences and needs demanded in the academic institution; by the degree of ease or difficulty of use of the mobile device; and on the degree of experimentalism and novelty.

To all this, we have to add that the mobile device user gets immediate progress indicators in any of the actions that are running at the time, leading not only to instantaneous feedback, but also to immediate feedforward that helps the individual to resolve any doubt or difficulty that may arise in real time. Through the feedback and feedforward, besides providing with information on their level of performance compared to the previously set goal or objective, teachers, students, friends, and users in general learn together to share ways of action that will enable them to make a leap between the cognitive level that is broken and that which is aspirated (Iglesias, 2012; Iglesias, Pedrero & Beltrán, 2013).

Added to all these questions, the authors would like to note that as people carry mobile devices most of the time, the learning process can happen at any time and place, as you can learn in unimaginable places breaking boundaries between formal and non-formal education, and ensuring thereby that the learning that takes place inside and outside academia is mutually supportive and responds to the diversity of people and situations in which we usually live, thanks to the many possibilities offered by technologies such as expanding texts, voice transcription, location detection and text reading, etc.; breaking all barriers to access and communication for people with disabilities (García & Iglesias, 2014; Iglesias & García, 2014).

We are at a time when it is necessary to be competent citizens able to function in many and varied situations, contexts and realities. This makes the training provided to them be raised from a different educational approach in which the only task is to not only learning but also developing, acquiring and implementing various skills and

engaging in real and different contexts (Iglesias, 2009), also leading to new educational opportunities which largely depend on cultural experiences and significant events that are provided in the field of formal, non-formal and informal education (Iglesias & Beltrán, 2012).

In this sense, pedagogy incorporates the socio-constructivist and meaningful patterns and cognitive-contextual paradigm where the individual is the true protagonist of learning, a learning process that has to be active, which is to allow the development of knowledge and learning in a social context, and understanding it through the concept of development and reprocessing (Keagan, 2005), to the detriment of traditional models that solely focus on the contents.

The applications of mobile learning are based on the analysis and representation of the various situations in which a person can be found, and the ways in which they respond to them based on individual, technical, material or those elements which are of value to the action, aimed at finding an appropriate solution taking into account the interaction between the scenario in which the situation and / or problem occurs and the individual. Thus, the process of teaching and learning generated by the use of these mobile devices is not only situational but also personal and psychosocial deriving, as Vygotsky would say, in a shared learning and socializing. Students learn through strategies built from new ideas and previous knowledge, acquired through motivation, and mobile applications depending on it generate virtualization scheme contexts, tools for managing this knowledge, and search methods of information relevant to the problem. Since the virtual scenarios in which the student works are interactive, diverse and changing, mobile applications must have an added value, the detection of the context in which they are immersed and the presentation of ad hoc information depending on the situation, place or time where the student is located (Iglesias, 2010, pp. 40-41; ISEA, 2009, p. 17).

It could therefore be said that mobile learning is based on the investigation and the effort that the uncertainty of training, deepening into the personal and inquirer styles of both the action of the student and the way that he-she has to understand the learning tasks he-she has to internalize, trying to place him/her at the challenge of the new and the need to accommodate his/her way to meet the demands of society and of himself, considering the interpretation and assessments around the training activities undertaken.

It must be borne in mind that mobile technologies offer mechanisms of interaction between knowledge and educational solutions tailored to the needs raised and the parties involved in the process, for communication to happen and, therefore, collaboration would not be possible without the communicative act. The communicative act is to be understood as the existential interactivity between people who want to exchange ideas, problems, ways of perceiving reality, etc., thus providing with a practical view that favors a more empathetic and collaborative virtual climate, which simultaneously favors an interactive-educational exchange between users. In that moment, the insider will decide what s/he wants to learn, how s/he wants to learn it (Zapata-Ros, 2012), when and by what means, given the speed with which communication and access to resources occur; to work with mobile devices involves organizational, structural, social implications of previous analysis, technology, thought and action (García & Iglesias, 2014; Iglesias & García, 2014).

In this regard, the authors can say that the mobile learning on the one hand, allows to work in two or more spaces depending on the need of the user, who may have started activities in a classroom environment and finish them in a virtual one or vice versa; and on the other hand, provides users with multiple possibilities as

1. Greater independence of the individual;
2. Creating its own space;

3. Support of everyday actions;
4. Ubiquity;
5. Media convergence in one device; and
6. Permanence (Sanz, Cukiermer, Zangara, Santangelo, Gonzalez, et al., 2007).

These issues remind us that it is an important issue and we have to attribute the appropriate role to technology in each case, we must ensure that these mobile technologies are used appropriately, taking full advantage of the use thereof (Zapata-Ros, 2012).

3. MAIN FOCUS OF THE CHAPTER

As it has been described in previous sections, mobile devices have taken a leading role as assistants of the learning processes, and, more specifically, as elements to enhance an ubiquitous and lifelong learning of diverse contents. Teachers, parents and educators in general, witness how youngsters use their mobile devices as elements to complement their educational process, looking for information in the web or using applications (hereafter Apps) to suit a series of purposes, as stated in Woolgar's third rule of *virtuality*: 'virtual technologies supplement rather than substitute for real activities' (2002, p. 16).

The main communicative purpose of the gadget has therefore been diverted to a much wider aim: accessing services and information from the palm of our hand. It is nowadays common to see how students at tertiary level use mobile devices in the classroom to solve their doubts and look for resources to complement their knowledge, a pedagogic service upon which the authors have based our study. To mention one example, in foreign language classes, apps which provide access to the lexicon of a language (thesaurus, dictionaries, etc.) are a common resource among students to look for the meaning of words they don't know, or to check the translation of terms in texts, tasks and other class materials and assignments.

Besides using their tablets and smart phones in the classroom, users of these devices have downloaded a series of apps which help them spending their free time in an entertaining and informative way. As a result, each mobile device is a reflection of the personality, tastes and hobbies of the owner, a virtual environment in which we download those apps that enable us to do what we like best: play music, have fun, take pictures or read a newspaper. One of the evident purposes why apps were created is making our daily tasks easier, either by monitoring our progress jogging or our agenda, or, why not, recording our learning process in a foreign language.

In this chapter, the authors describe a study carried out at tertiary level in two Spanish universities during the academic year 2013-2014. The authors took as a basis the use of mobile devices among students for communicative and playful functions, and wanted to explore their perceptions about smart phones and tablets being tools to learn English. The research presented here has been carried out by members of the ATLAS (Applying Technology to Languages) Research Group, in the framework of SO-CALL-ME Project (Social Ontology-driven Cognitive Augmented Language Learning Mobile Environment, Ref. FFI 2011-29829), leaded by profs. Elena Bárcena and Timothy Read (UNED, Madrid), and which investigates in areas such as Mobile Assisted Language Learning (MALL), E-learning and Languages in Primary/Secondary/Tertiary Education, Computerized Language Testing and Assessment, Distance and Lifelong Language Teaching/Learning, ICTs and Languages for Specific Purposes (LSPs) or Technological Innovation in Terminology and Translation.

ATLAS research group aims to emulate an experimented English teachers, using Artificial Intelligence (AI) strategies and techniques to work in Computer-Assisted Language Learning (CALL) and Mobile-Assisted Language Learning (MALL) fields, giving a comparable relevance to the different types of communicative and lin-

guistic competences (written/oral, production, interaction/reception) to make the discipline move a step forward from a linguistic, pedagogic and technological foundation.

3.1. Objectives

Within this framework, the study the authors describe in this chapter set as its departure point the leading role that ICTs have achieved, focusing on mobile devices as assistants of the learning processes and elements to enhance an ubiquitous and lifelong learning of languages at tertiary level. The general objective of the research is to get to know the habits of students regarding the use of mobile devices and their expectations towards a pedagogical use of these gadgets to learn English.

With this study, the authors aim to:

- Contribute to making mobile devices an autonomous learning resource in higher education in Spain.
- Know the opinion of students on the use of mobile apps to boost their English learning process.
- Get data that allow us to develop and design better apps in the near future, and/or adapt them to the needs of its users.
- Try to increase motivation among students towards the practice of language skills outside the classroom.
- Provide students with the awareness that mobile apps can help them in their learning processes as well as with a critical perception to assess them.

3.2. Subjects Involved

To meet the objectives, the authors involved students from the University of Salamanca (Spain) and National Distance Education University (Madrid, Spain) who volunteered to participate in the study. The sample consisted of 132 answers to the questionnaire. The students belonged to any of these subjects:

- *English V:* Degree in Tourism (USAL);
- *English B1*: Primary Education Teacher Degree (USAL);
- *English Language:* Degree on English Studies (USAL);
- *Oral Communication in Early Language Learning Environments:* Primary Education Teacher Degree-adaptation Course, English specialty (USAL);
- *Oral Communication in Early Language Learning Environments, Primary Education Teacher Degree, English specialty (USAL);*
- *Instrumental English II:* Degree on English Studies (UNED).

3.3. Methodology and Resources

The working methodology followed in this research the authors present follows a collaborative approach, in which students participate in the study not only as users of mobile applications for learning foreign languages, but also as informants in the process and key elements around whom the work that takes place in this research rotates.

The working methodology followed in this study has three main processes:

1. **Plan:** The authors collectively planned each of the steps, detailing specific actions to be carried out.
2. **Implement:** The different activities planned have been carried out (students' training, data collection, etc.).
3. **Measure:** The authors analyzed the data obtained and measured, therefore, the degree of student satisfaction with the process and the degree of compliance with expectations.

The authors have obtained not only quantitative but also qualitative results, leading to a number of relevant conclusions for improving the inclusion of apps in teaching-learning processes.

The resources used in the implementation phase were very basic, as mobile devices were provided by the students, who had to use their own gadgets to participate in the study. The authors used Moodle platform (*Studium* at the University of Salamanca) to monitor, train and organize the collaboration and information of students. The resource used for data collection is a questionnaire that was designed by the team of teachers working in the study to enquire about those aspects which could provide us with relevant information about the students habits, opinions and expectations. Moreover, for the analysis of the students' answers, the authors benefited from the data analysis tool from Google, thus incorporating the Information and Communication Technologies (ICTs) to all the stages of our study.

3.4. Activities Developed and Its Phases

This study has been carried out in several consecutive stages, which have been devoted to different tasks and meet different goals:

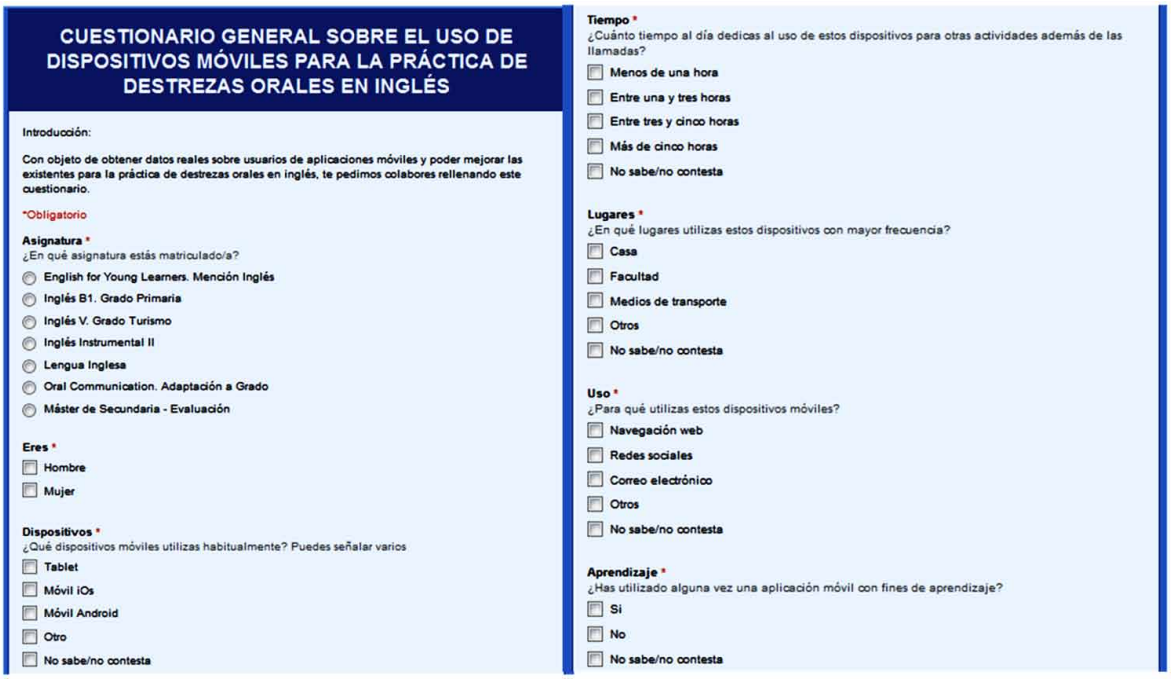
Phase 1: Starting the study. Analysis of sources. The implementation of the research process involved the need to collect information on the existing uses of mobile learning in foreign language classrooms, especially on previous experiences of implementing the use of mobile applications to supplement classroom teaching activities in the university system. With the creation of this literature, the working group formed the theoretical basis on which we could start working, being always subject to extension by team members, which has actually happened throughout the entire process. The collected materials are stored in a library opened in Google Drive, so that materials can be used by all members in future research.

Phase 2: Survey design. At first, the members of this research jointly designed a survey to collect information on the opinion of students on the use of mobile applications to improve the skills in English. Through this survey, the authors have collected students' experiences in mobile learning, as well as their views on the usefulness of mobile language learning. The questionnaire was designed in Spanish using Google Questionnaires tool, so the authors got a very satisfactory result, with a very nice interface for the users, and with an easily embeddable format on electronic media, such as web pages or the Moodle platform *Studium*, as it can be seen in Figure 1 (original material in Spanish).

The questionnaire, as seen in Figure 1, offers the user a series of multiple choice questions from which you can choose one or more valid responses, depending on the question asked. This questionnaire, once completed by each of the participating students, was automatically sent to a *GoogleDrive* research folder, so that all members of this research can monitor the evolution of students' responses.

Phase 3: Participating students' formation. For the training phase of the participants at the University of Salamanca, a site was created in the Moodle platform *Studium*, where the training phase for students about mobile language learning was conducted, focusing on the characteristics and availability of applications for learning and/or practice of oral skills in English. The information provided by UNESCO on mobile learning and e-learning, on their website was used for these purposes: (http://www.unesco.org/new/es/unesco/themes/icts/m4ed/)

Figure 1. Questionnaire of general information on the use of mobile devices to learn English



CUESTIONARIO GENERAL SOBRE EL USO DE DISPOSITIVOS MÓVILES PARA LA PRÁCTICA DE DESTREZAS ORALES EN INGLÉS

Introducción:

Con objeto de obtener datos reales sobre usuarios de aplicaciones móviles y poder mejorar las existentes para la práctica de destrezas orales en inglés, te pedimos colabores rellenando este cuestionario.

*Obligatorio

Asignatura *
¿En qué asignatura estás matriculado/a?
- English for Young Learners. Mención Inglés
- Inglés B1. Grado Primaria
- Inglés V. Grado Turismo
- Inglés Instrumental II
- Lengua Inglesa
- Oral Communication. Adaptación a Grado
- Máster de Secundaria - Evaluación

Eres *
- Hombre
- Mujer

Dispositivos *
¿Qué dispositivos móviles utilizas habitualmente? Puedes señalar varios
- Tablet
- Móvil iOs
- Móvil Android
- Otro
- No sabe/no contesta

Tiempo *
¿Cuánto tiempo al día dedicas al uso de estos dispositivos para otras actividades además de las llamadas?
- Menos de una hora
- Entre una y tres horas
- Entre tres y cinco horas
- Más de cinco horas
- No sabe/no contesta

Lugares *
¿En qué lugares utilizas estos dispositivos con mayor frecuencia?
- Casa
- Facultad
- Medios de transporte
- Otros
- No sabe/no contesta

Uso *
¿Para qué utilizas estos dispositivos móviles?
- Navegación web
- Redes sociales
- Correo electrónico
- Otros
- No sabe/no contesta

Aprendizaje *
¿Has utilizado alguna vez una aplicación móvil con fines de aprendizaje?
- Si
- No
- No sabe/no contesta

To carry out this research, collaboration was sought to students from various degrees, who have completed courses in English Instrumental / English for Specific Purposes during the year in both semesters, asking for their voluntary and disinterested participation.

The six subjects in which collaboration was asked to students are those in which, at least, one member of the research study teaches courses: English Language (Grade in English Studies), English V (Degree in Tourism), English B1 (Grade in Primary Teacher Education), Oral Communication in Early Learning Environments (English specialty, Primary/Pre-Primary Education Degrees) and Assessment in English (Master Program in Secondary Education Teaching, Vocational Training and Language Teaching).

A total of 130 students from both universities involved volunteered to participate in the study and responded to the survey, data from which there results shown later were obtained.

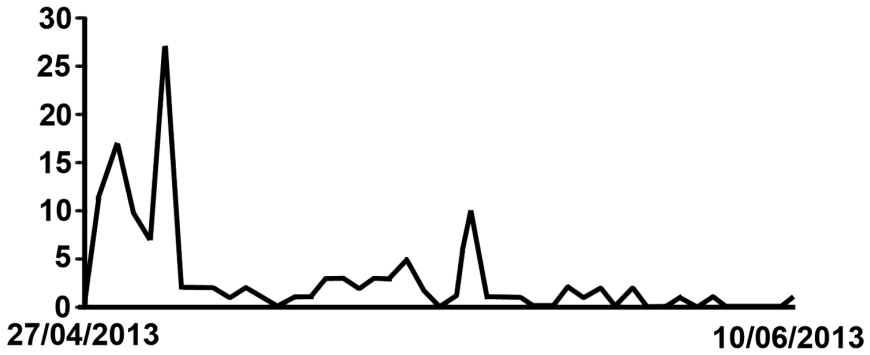
Phase 4: Collection and analysis of the students' answers to the survey, detailed examination of the results obtained for each item in the test and graphic representation of the data.

Phase 5: Interpretation of the results obtained in the light of previous researches carried out and design of lines for future research.

4. SOLUTIONS AND RECOMMENDATIONS

Once the surveys were implemented, the authors quantitative and qualitatively analyzed the data obtained from each item, to draw relevant conclusions on the process followed. The majority of students responded in the first days in which access to the Moodle platform was opened, but the authors have recorded continuous accesses and responses, as shown in Figure 2, during the whole semester in which the study was carried out:

Figure 2. Temporal evolution of responses from participating students



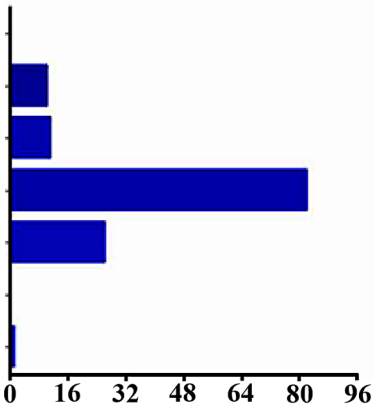
Hereafter, the authors present a series of graphs, derived from the analysis conducted of the data collected, about which the authors will comment on the most important aspects.

As it can be seen in Figure 3, a great majority of the students who participated in the study as volunteers came from a subject on general English, the subject with the highest number of students registered as well, so the correspondence between the number of students per subject and the people who offered as volunteers is more or less proportional.

Regarding the gender of the students who answered the survey, there is a significant difference between male and female students, as a 79% of the volunteers were women, opposed to a 21% of men. It is also true that the authors have to take into account that the number of female students enrolled in the Degrees to which the subjects belong is much higher, thus following the traditional division between men and women when choosing their professional future, as shown in Figure 4. All the Degrees involved are language or education-related and the percentage of male students in the classrooms is not yet equivalent to that of women, although there is a tendency towards balancing the presence of both genders in the classroom in the last years.

One of the aspects about which the authors wanted to get information was the type of mobile devices that they use. The authors know for sure that they all have access to a tablet or a smart phone in their daily life, but the type of device and, as a consequence the type of operating system that they use was still unknown. The authors are interested in the operating system that is mostly

Figure 3. Subjects in which students are enrolled



English for Young Learners.	**0**	0%
English B1. Primary Degree	**10**	7.6%
English V. Tourism Degree	**11**	8%
Instrumental English II	**82**	623%
English Language	**26**	20%
Oral Communication.	**0**	0%
Secondary Ed. Master	**1**	0.8%

Figure 4. Gender of the students polled

used among students, because that will help us to orient the design and implementation of apps as educational resources in the classroom, which will have to be carefully thought and planned to adapt the mobile devices in which it will be used. As it can be seen in Figure 5, Android smart phones are the most common devices used, in an 85% of the cases. After them, the second most commonly used device is the IPad, closely followed by IPhone and other devices. The possession of tablets among students is yet not as high as that of mobile phones, and the results confirm that they still use the mobile phone as the only device to access apps and contents. Nevertheless, the authors now know that Android still primes over IOs as the preferred operating system among the students who attend the subjects involved in this study, and consequently, those at Spanish universities nowadays.

In relation to the time they devote to using mobile devices, a 42% of the students answering the survey answered that they normally use the mobile device between one and three hours a day for purposes other than purely communicating. A 27% of them declared using these devices less than an hour per day, a 22% said they use the device between three and five hours a day, and a 10% of the students do it for longer than five hours. As it can be seen in Figure 6, the time dedicated to using mobile devices is, as expected, quite high among the students at university. The majority of them spend around four hours using a mobile device, time which, as the authors point out in this study, could be used to practice and reinforce skills and contents dealt with in the classroom.

Once the authors had obtained data about the average time of use of mobile devices, the authors wanted to know in which places does that usage occur with a higher frequency. The authors know that some of our students have to daily use different means of transport to reach the university, temporary slots which are normally boring and unattractive for them, and when, as the authors suspected, a 40% of the students use their mobile

Figure 5. Mobile devices most frequently used

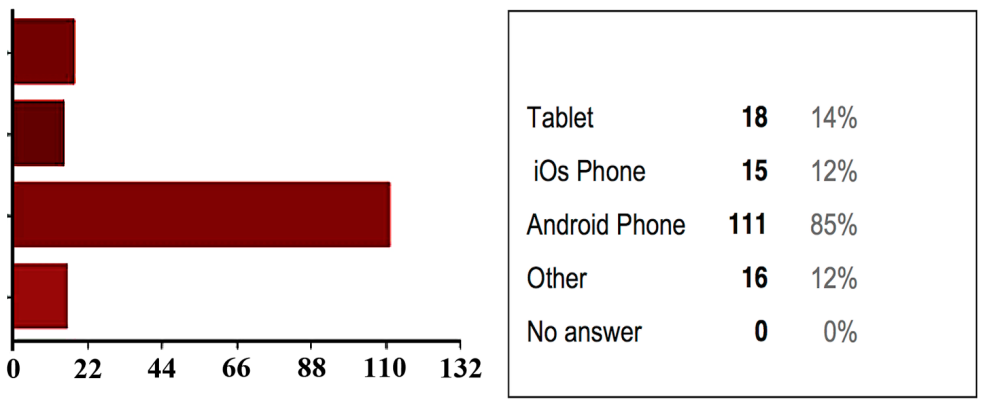
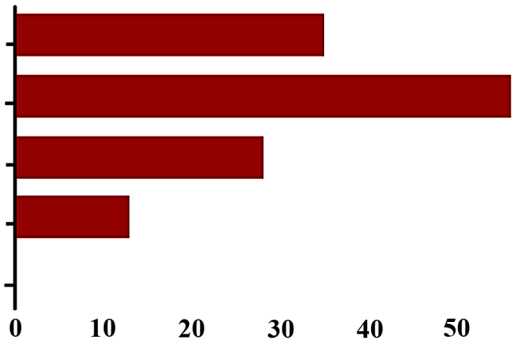


Figure 6. Time devoted to the use of mobile devices

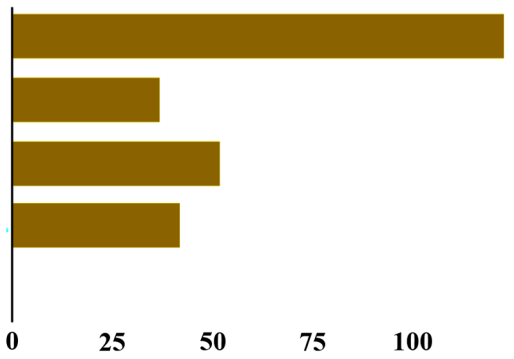


Less than 1 hour	**35**	26.7%
1 to 3 hours	**56**	42.7%
3 to 5 hours	**28**	21.4%
More than 5 hours	**13**	9.9%
No answer	**0**	0%

devices to amuse themselves in that time. A majority (92%) of the students polled answered that it is at home when they mostly use mobile devices, and a 28% declared using them at the faculty as well, as it can be seen in Figure 7. A 32% stated that they use mobile devices also in other places different from those earlier mentioned, data which reinforce the aforementioned property of learning through mobile devices: ubiquity. If our students have declared to use mobile devices in a variety of places and environments, the authors can therefore benefit from the ubiquity property and encourage them to continue their learning process wherever they want.

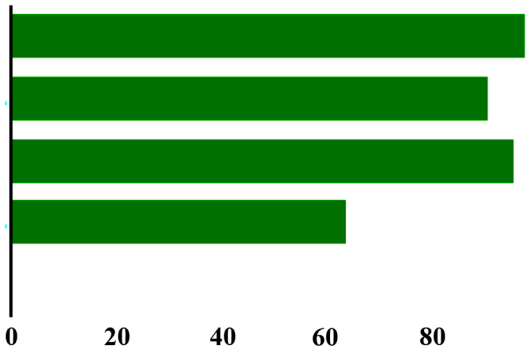
In relation to the uses that students make of their mobile devices other than communicating, the authors find that there are three main tasks that attract the time spend using mobile devices. On the one hand, and almost equally distributed, students declare to use their mobile devices to access the Internet and to check their mail. The higher proportion of the time spent using a mobile device is therefore devoted to looking for information in the net or sending/reading a personal mailbox (75% and 73% respectively). Closely following that percentages, students spend their time on social networks, such as *Facebook*, *Tuenti* or *Twitter*, where they exchange pictures and comments with friends and acquaintances. Almost 50% of the students admit using their mobile devices for purposes different than surfing the net, checking mail or social networking, a good number of students who could possibly spend their time playing with a downloaded app and therefore turn the former communicative device into a playful gadget, as shown in Figure 8.

Figure 7. Places where mobile devices are most frequently used



At home	**123**	93.9%
Faculty	**37**	28.2%
Means of transport	**52**	39.7%
Others	**42**	32.1%
No answer	**0**	0%

Figure 8. Use of mobile devices



Web browsing	98	74.8%
Social networks	91	69.5%
email	96	73.3%
Others	64	48.9%
No answer	0	0%

When asked if they have already used their mobile device for learning purposes, a 59% declare to have already experienced learning through a mobile device, while a 41% state not to have used them as educational resources yet. This question provides us with relevant data regarding the popularity of pedagogical apps among students. As it can be seen in Figure 9, less than half of the students perceive mobile phones or tablets as learning devices, which are considered for the above mentioned purposes, but not to acquire or practice knowledge. As a consequence, half of our students have still to be convinced that mobile devices can be integrated into their academic process, and they can greatly benefit from their properties (attractiveness, ubiquity, accessibility…) to boost and improve competences.

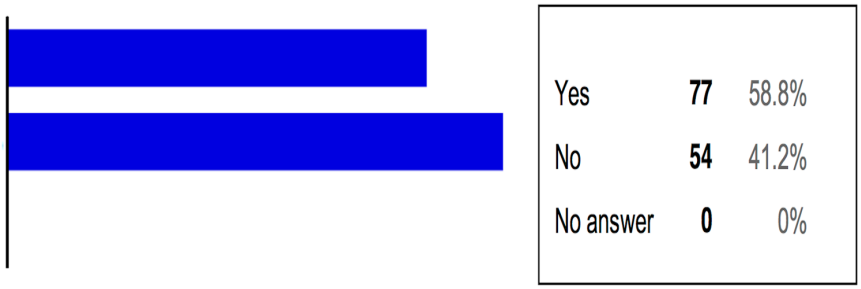
Taking into account these figures, the next question in the survey asked them about their experience on learning English through a mobile device. Half of the students who answered to the survey said that they had already used an app to learn or practice their skills in English, and the other half declared not to have still used apps for second language learning, as can be seen in Figure 10. The fact that half of them have already used an app for learning English favors the future of this research, conducted to get information, at a very basic and first stage, to later on, be able to design and develop apps for our students to practice what they learn in the English classroom at university.

Accordingly, the authors asked them about their expectations towards the use of an app in a mobile device to learn English, and a 50% of the students said they have high expectations towards apps as resources to learn a language. A 12% declared to have very high expectations towards it, and a 35% said to have an intermediate level of expectations. Only a 4% said they don not believe in apps as language learning devices, a very low percentage that provides us with the information that students are receptive about using apps in the

Figure 9. Usage of a mobile app for learning purposes

Yes	77	58.8%
No	54	41.2%
No answer	0	0%

Figure 10. Usage of a mobile app to learn English



foreign language classroom, and, moreover, that they have a high expectancy on the pedagogical value of the devices, as shown in Figure 11.

Finally, students were asked about the type of skills that they would mostly like to practice through a mobile device or an app, and the results obtained do match the expectations of the team of researchers. Spanish students traditionally show the greatest deficiencies in communicative skills, as they lack competences both to understand real speech and to communicate themselves fluently. Students themselves realize these difficulties and are, nowadays more than ever, conscious that efficiently communicating in a language involves orally receiving and sending messages. As a consequence, the students who answered to the survey express that they would like to practice what they are less competent in: listening and speaking. These oral productive and receptive skills are followed by the preference for grammar, the traditional heart of language learning, and which, as it seems, is still fashionable among students, though not so much among language teachers these days.

In a lower percentage, they express they would also like to deal with reading exercises and context-specific situational conversations, as can be observed in Figure 12.

5. CONCLUSION

On the one hand, as it has been stated in the introductory sections of this chapter, learning, more than ever, must be conceived as a dynamic and not static, cumulative process that takes place throughout life (lifelong learning) and in a non-linear way, without being relegated to space and classroom time and giving the user the opportunity to freely choose learning times and spaces, according to the

Figure 11. Expectations about the use of a mobile app to learn English

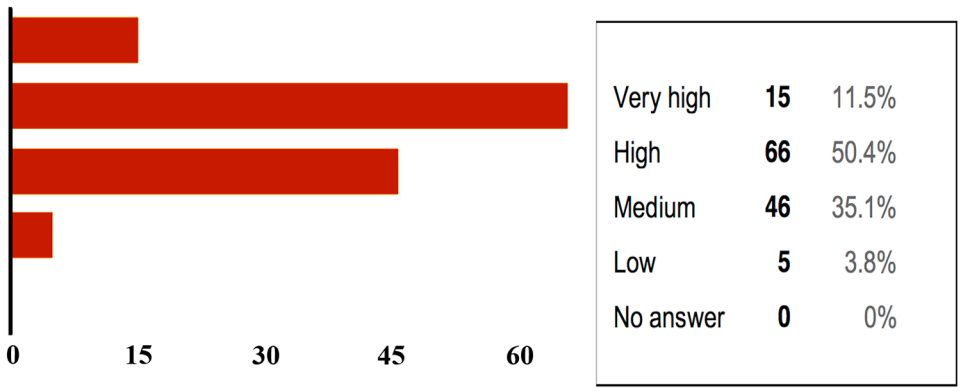
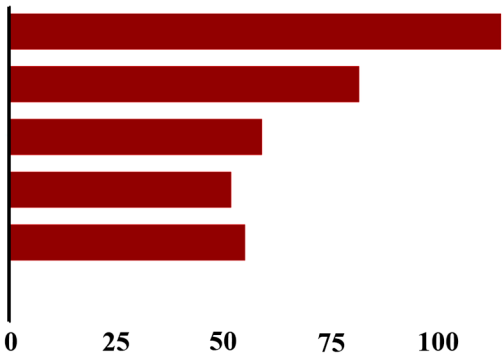


Figure 12. English skills that they would like to practice using a mobile app



Listening	114	88%
Speaking	81	62%
Grammar	59	45%
Reading	51	39%
Specific conversations	55	42%
No answer	0	0%

requirements demanded by the different personal and academic contexts of the students. Currently, Mobile Learning allows the use of mobile devices in teaching and learning practices of almost any subject or topic of interest. In this sense, language learning through the use of these mobile tools is gaining a special boom given the pressing need to stay updated on the skills demanded by society in general and the labor market in particular. Taking this basis into account, in this chapter the authors have described a research in which the authors got data about the use that university students make of mobile devices, and more specifically, about the use of apps for learning purposes.

On the other hand, and having a thorough look at the data the authors have shown in the previous section, the authors can draw a number of conclusions relevant not only to the successful development of this research, but also for the implementation of initiatives including mobile devices and applications for learning in general, and, more specifically, for learning languages.

In light of these results, the authors can conclude that the devices from which our students mostly use applications are phones with Android operating system, followed by tablets from Apple, which are increasingly getting a place in the market. This fact makes us guide the design of future applications to the two operating systems, with special attention to the specifications for download and use on every operating system.

These devices are generally used between one and three hours, although there is a remarkable group of students who manifest that they use them less than an hour a day. Given this trend in use, the authors believe that it is more convenient to create applications involving limited time use, never beyond the total time of use of the devices, which, as the authors have also included in this questionnaire is distributed in a very balanced way between web browsing, email checking and using social networks.

A large proportion of students declared using mobile devices at home and also at a number of means of transport, places that have turned into mobile learning spaces, allowing greater flexibility in the classroom, key data that reinforce the need for further research in this field.

Regarding the purpose of the use of mobile devices, 60% of students said that they had already used mobile applications for educational purposes, which sets us in a good line of work. These data are very important for us, because they indicate that students have internalized in their lives the role of the devices as teaching agents, and, therefore, seek and consume applications that pursue this aim. Many of them, however, have not yet used the devices to learn English, but clearly expressed their high expectations about practicing or improving their English by using mobile applications.

In conclusion, it should be noted that most of the students would like to use mobile applications

to practice Listening activities (oral reception), followed by students who are attracted to the idea of conducting activities Speaking (oral production). This data is highly representative for this research and confirms the preference of students towards oral skills, which opens the field to deepen our research on English teaching-learning applications. Nevertheless, we have to bear in mind that data was collected under a series of specific conditions (time, degree, students…) and thus the results obtained can be taken as reference preferences in higher education, although not extrapolated as universally applicable.

6. APPLICABILITY OF RESULTS TO THE ARCHITECTURE FIELD

Studies of architecture in Spain are characterized, among other things, by training students and future professionals in the development of skills and knowledge, both in a creative and technical way. This type of training provided to them is atypical in a global market in which the formation of the architect is distributed among various professions. The difference is that, in turn, makes architecture students be prepared with a unique training to enter the labor market, not only because of their prestige, but also because they have a worldwide unmatched holistic view.

The high quality of architects' training in terms of technical knowledge, ability and responsibility to build structural facilities, coupled with its ability to design and control work quality, so appreciated in the international market, can not detract from a lack in learning foreign languages like English, restricting their ability to exclusively work in consolidated national markets, which because of the situation of economic gravity in which Spain is immersed nowadays, cannot cope with future expectations that have offered so far.

Since it is in the international market where the professional future of new generations will have to be developed to a great extent, it is essential to place greater emphasis on training students in the study of languages that support the development of language skills, communication and business abilities to facilitate their entry into the labor market in a foreign country. And it is here where the relevance that Mobile Learning is gaining in recent years, because thanks to the opportunities it provides, there are more and more pedagogical experiences that rely on technological aids that make foreign language learning possible, provided that the design and development of appropriate teaching materials, the interaction and collaboration of linguists, programmers and engineers, and the implementation of new way of organizing the teaching of languages in which the teacher must perform new features to meet the specific stage of student learning are performed. The multiple possibilities offered by Apps to practice any discipline, and especially a foreign language as necessary in the studies of architecture to which we are referring as English, are an important complement to traditional classes, offering students the chance to experience a different way of learning and practicing a foreign language. This is favored by the task-based approach, whose main objective is to create situations in which architecture students have to use the foreign language to manage professional situations related to construction, to extend vocabulary by learning specific terminology the language of construction and architecture, to understand the phases of study management, construction and project contracts at European and international level, to know vocabulary techniques applied to sustainability and energy efficiency, to recognize and distinguish the different structural elements in English, to read technical construction plans, to acquire work management vocabulary, etc.

In short, propose an action plan to help the students achieve a practical result oriented to foster in them the reflection, criticism, scenario development and research work through a process in which everyone has to take responsibility for learning, applying their knowledge and skills to real projects. Therefore, it favors a learning process

oriented to action in which several areas or materials necessary for their professional and personal development are integrated. In this context, it can be said that the learning needs no longer depend on the judgment of the teacher, but arise from the activity itself (Duke & Ibáñez, 1999-2000, pp. 84-85). In this sense, mobile learning is built on technology par excellence of the new century

… provide regular and comprehensive access to systems and applications that support formal and informal learning anytime and anywhere, giving the opportunity to learn to control and use their available time for learning / review of (new) knowledge. (Romero Molina & Chinino, 2010, p. 123)[Authors' translation]

The data obtained in this study must be put at the service of users, so they can satisfactorily integrate and design Apps in the educational field of architecture, improving the care provided to the student by creating specific applications, focusing on the needs of people, intelligently and autonomously reacting to them, thereby improving the student experience within the educational and professional environment in which s/he gets on. Weiser in 1991 already stated that the technologies that influence more in society are those most unnoticed. For this reason, the study presented in this chapter aims to take a step forward in the design and development of innovative mobile learning applications that truly complement and enrich the educational learning experience or review of language knowledge in different professional contexts, among which are the studies of architecture.

That is to say, we have to seek and find the right place that mobile devices of this kind have to occupy in architecture studies, as a supplement to traditional teaching, as it is not just a matter of valuing the immediacy of its use anywhere and at any time, but also of providing an individualized educational experience adapted to the personal characteristics of each student, giving the opportunity to learn at the most appropriate moment, place and context in relation to his/her objectives and learning style (Martin & Romero, 2010). For example, following learning levels established by Hug (2009), we might consider language learning in the field of architecture in the macro-learning level, since it encompasses all aspects of complex semantics and socio-cultural characteristics of the language. At a meso-learning level we would find situations or specific episodes of the studies in question (architecture). And, at micro-learning level, sentences, phrases or words of language for specific architecture studies.

As it can be seen, the use of mobile devices such as those presented in this chapter, broadens the spectrum of possibilities for the construction of knowledge, strengthening understanding, contextualizing the learning provided in classrooms, providing with significance to the contents learned and self-assessing the learning process by those who experience it. This is the best indication for further work in this direction, maximizing the potential of next generation technologies.

7. FUTURE RESEARCH

Following the research presented here, a second stage of this study is already developing, a step forward in which the authors want the students to actually act as testers of educational apps and provide us with their perceptions when using mobile devices as educational resources. In this second stage of the research, the authors want to get data about the degree of satisfaction of students –as users- of apps to learn languages, and more specifically, to learn English. In this study, the authors will ask the students to first answer a survey on their expectations, prior to the use of the app, and their beliefs about the educational power of such a tool. Afterwards, they will download and use an app to practice skills in English (reading, listening, speaking…) and value the results and the advance that they have achieved with the use of the app and the device. Google Forms will be used to design and implement the polls to the

students, and also benefit from its tool to analyze and extract relevant data about the performance/ opinion of students. With this second stage of the study, the authors want to actually incorporate the use of mobile devices and apps into the real activities carried out in subjects at tertiary level, making the students realize that they can rely of technological tools to practice skills learned in class or to learn new aspects of the language studied. The authors have high expectations about this part of the study, as students will feel motivated and positively predisposed to the pedagogical use of devices which are already so familiar for them. The final goal of the study is to better know the applications and skills that students prefer using, how they work and in which way they do help students improve their level, to eventually get a list of requirements, both pedagogical and technical, for apps to be successful for English skills' practice.

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KEY TERMS AND DEFINITIONS

E-Spaces: Virtual spaces of shared knowledge in which digital natives can perform all kinds of educational activities both in formal and in informal and non-formal.

Insiders: Digital natives are able to use technology effectively and solve problems they encounter without programming skills or have a comprehensive technical knowledge of ICT.

Interdisciplinar: Areas of expertise that relate to various scientific and cultural disciplines.

Mobile Devices: Set of small technological tools (phones, PDAs, tablets, ...) that allow us to process information, connect to the Internet, perform various operations and use them anytime and anywhere.

Multidisciplinar: Partnerships between professionals from different disciplines aimed at achieving the same goal.

Neuroarchitecture: The study of the relationship between health and the management of spaces through the contributions made by the neurosciences. That is to say, studies the relationship between brain processes and architectural environments and their impact on the emotional and physical health of people (www.anfarch.org).

Neurodidactics: Teaching science that studies the full potential of human beings, from early ages of life to old age, thanks to this feature called 'brain plasticity,' which indicates that the human brain continuously learns and adapts.

Ubiquitous Learning: The learning which can take place at any time and place benefiting from the use of technologies to implement learning processes derived from solving several tasks assigned to the students.

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