Motivación y mejora académica utilizando realidad aumentada para el estudio de modelos tridimensionales arquitectónicos

Motivation and Academic Improvement Using Augmented Reality for 3D Architectural Visualization

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Abstract

This paper discuss about the results from the evaluation of the motivation, user profile and level of satisfaction in the workflow using 3D augmented visualization of complex models in educational environments. The study shows the results of different experiments conducted with first and second year students from Architecture and Science and Construction Technologies (Old Spanish degree of Building Engineering, which is recognized at a European level). We have used a mixed method combining both quantitative and qualitative student assessment in order to complete a general overview of using new technologies, mobile devices and advanced visual methods in academic environments. The results show us how the students involved in the experiments improved their academic results and their implication in the subject, which allow us to conclude that the hybrid technologies improve both spatial skills and the student motivation, a key concept in the actual educational framework composed by digital-native students and a great range of different applications and interfaces useful for teaching and learning.

Resumen

En el presente artículo discutimos los resultados de evaluar el grado de motivación, el perfil y el nivel de satisfacción de los estudiantes en flujos de trabajo que utilizan la visualización aumentada de modelos complejos en 3D. El estudio muestra los resultados de experimentos realizados con alumnos de grado a lo largo de los dos primeros cursos de Arquitectura y el actual grado de Ciencias y Tecnologías de la Construcción (antiguo grado español de Ingeniería de la Construcción, y con cuyo nombre se reconoce a nivel europeo). Hemos utilizado un método mixto que combina el uso de técnicas cuantitativas y cualitativas de evaluación de la respuesta del estudiante, con el fin de completar una visión más global del uso de nuevas tecnologías, dispositivos móviles y métodos visuales avanzados en campos académicos. Los resultados nos muestran cómo los estudiantes partícipes de dichos experimentos han mejorado sus resultados académicos y su implicación con la materia, un punto clave en el actual marco educativo compuesto por estudiantes nativos digitales y un gran número de aplicaciones y dispositivos para la enseñanza y el aprendizaje.

1. Introduction

Information Technology (IT) represents a set of tools and applications that allow the incorporation and strengthening of new educational strategies, many of which have been defined in new teaching frameworks in the last two decades (Dede, 2000). In recent years, the use of ITs has spread to all levels of our society. The affordability of prices and the popularity of devices and applications have enabled its ubiquitous presence in leisure, relationships, work activities and of course teaching. The adaptation of contents and applications in this area has emerged as an interesting field of study to assess the degree of motivation, satisfaction and usability of students Redondo, Sánchez, Fonseca & Navarro, 2014), and their academic improvement (Fonseca, Martí, Redondo, Navarro & Sánchez, 2014).

New technology implementations in the teaching field have been largely extended to all types of levels and educational frameworks. In recent years, in addition to technology use in the classroom, new areas of research are opened to assess and recognize more effective and satisfactory teaching methods, such as: Gamification strategies, Project Based Learning (PBL), Scenario Centered Curriculum (SCC), and the recognition of capabilities that provide the non-formal and informal education (in this case it is still in a very initial state and where they are studying the best methods and systems for inclusion in the assessment of educational improvements). The use of IT in learning methods, especially at the level of a degree and/or a master in frameworks related with Architecture, Urban Planning and Design, or Building Engineering, is defined in the new academic plans. It is important that the student should be able to get competencies and skills related with active and collaborative learning, and digital information management, all of them using roles and PBL exercises. All of these methods are prepared for a more quick and effective capacitation of the student in front of the classic educational methods. For these reasons, it is necessary to propose new educational methods that complete the actual PBL and SCC systems, increasing the student motivation, and their involvement and performance. The interest of educators in using these technologies in the teaching process supposes greater engagement and an increase in the students understanding of content (Roca & Gagné, 2008; Kreijins, Acker, Vermeulen & Buuren, 2013; Shen, Liu & Wand, 2013), leading to an improvement in academic results.

To evaluate these premises, we have been conducting during these past three years, different case studies to design and compile different data and results. This strategy was defined in order to study new methods to improve both academic results and specific competences of our students, especially in a task as important as the visualization of complex models and buildings in 3D. Thus,

the standard approach is to start from formal educational approaches and quantitative studies, but it's been recently demonstrated (Fonseca, Redondo & Villagrasa, 2014), that qualitative approaches are equally valid and allow a more accurate characterization of the teaching experiences, especially when these involve IT. The present study has two main objectives: present the main results of the last cases developed, and then discuss the key concepts to take into account for future studies in order to improve any educational class that uses mobile devices and hybrid technologies for 3D visualization.

2. Background

2.1.New learning strategies: IT and Project Based Learning, *PBL*

Designing an educational experiment does not always work successfully. Involving new technologies and the use of various devices is not always synonym of an effective user experience (Rodríguez-Izquierdo, 2010). A good design to motivate and improve students' learning can be transformed into just the opposite. Any "Good Educational Practice" must have different parameters for monitoring and evaluating each exercise, environment and student. And on the opposite side there's the student's work. As a practical exercise it can perfectly meet all evaluable and pre-established criteria in technology and performance. But it would be necessary to check whether the proposal is also functional and usable (Sánchez, Redondo & Fonseca, 2012). This step is an essential step which is usually forgotten in the teaching faculties, mainly due to lack of time (Fonseca, Villagrasa, Valls, Redondo, Climent & Vicent, 2014), and where we focus our case study.

The interest, need, and urgency of implementing new technologies in education and universities is a relatively new situation (Rogers, 2000). However, technological innovation, which is intended to improve the student learning process, must be capable of providing support to address difficulties that could arise with the student in the use of and interaction with technological elements. These elements must not obstruct the auto-learning process, which is altered by this technology, and the students must be motivated with the new educational methodology. There is a natural reticence in the academic field about the use of technologies that are associated with leisure or personal relationships, such as mobile devices (Fonseca, Martí, Redondo, Navarro & Sánchez, 2014). Another major deterrent to implementing IT in teaching is the administrative environment: professors must be trained (Georgina & Olson, 2007) and must be capable of giving full-time support to students, the success of which is dependent on the professors' willingness and ability to devote the time required for the training, modification, and actualization of the related content.

To incorporate a new IT-based methodology into a specific teaching environment, some

recommendations for avoiding student rejection must be considered. The literature defines so-called "good educational practices" that are primarily focused on virtual rooms, distance education (or e-learning), and semi-present teaching (Area, San Nicolás & Fariña, 2010). In accordance with Massy & 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 activity and learning activities to utilize the new incorporated technologies and methodologies to improve the educational tasks.

Examples of educational methodologies that have implemented the two first objectives are common, but examples that incorporate the third objective are much less common. In this direction, we can find examples that are incorporating quite successful teaching strategies based on PBL, game design for tracking tasks (also known as gamification) and taking account of tasks, courses and activities that could encompass as non-formal or informal tasks.

In contrast to traditional programs (passive and focused on subject matter) a PBL (a specialization of the more general concept of SCC - Scenario Centered Curriculum), offers an experience equivalent to learning a trade: learners must face a well-planned series of real situations (scenarios) in a significant and motivating role. Within these scenarios, they must carry out precisely those tasks, activities and reasoning processes that are best suited for building the desired skills (Higueras, 2013). This way, learners facing a problem on their own notice why certain skills are useful. This type of program is the most common exercises that the civil and building engineering students are using as PBL systems.

However the 3D visualization and compression are skills and abilities which are marked in their learning, where virtual and environmental systems are being the ones that are showing better adaptation to such content. Additionally, we can find studies that have reflected the role of gamification and game-based learning (as a sub-model of PBL) in assessment within virtual environments, an example of systems that can improve the assessment while increasing efficiency and providing new opportunities for educators to use motivation and ubiquitous systems.

The combination between 3D models with urban information (specifically when this information can be viewed and managed ubiquitously) will allow students the acquirement of skills related to historical knowledge, project development, and urban planning. Future architects and planners, from early stages should be able to manage the SCC/PBL proposed, since in this particular field it is very

difficult to work with abstractions and simplified models. The use of ITs in education has a clear objective to promote an Enhanced Technology Learning (TEL), which in multiple forms (assistance and semi assistance), generating in one hand much more motivation and improvement of academics for students and on the other hand teachers have greater ease of monitoring and evaluation. Literature on use of explicit, pedagogical strategies dedicated to enhance creative problem solving is relatively scare (Retalis, 2011).

Thus, there is an open research and development issue on learning strategies that could effectively promote creativity and innovation. The design-oriented pedagogy for TEL (for example using exercises based on PBL) allow the students using collaborative environments to create and discuss new spatial proposals. This way improving both general and specific skills in the border of formal and informal educational environments (Vartiainen, 2012). Learning to collaborate and connect through technology is an essential skill that future societies will expect from its people (Binkley, 2011).

2.2. Hybrid Drawing/Representation: the new travelogue of architects

We can define the Digital Sketching (DS), as those drawn on mobile devices using pointers or gestures that mimic traditional techniques and require the same skills than traditional freehand drawing (Fig. 1, Redondo, 2010). These methods and systems support many more editing possibilities and make easier to share the work on the network, especially if compared to traditional travel sketchbooks. The union of these devices with the specific characteristics of digital drawing allows us to affirm that we are in front of the natural evolution of said travel sketchbooks and the on-site sketches or the sketches in the early stages of the project, which represent a large qualitative leap in the advance of architectural drawing.
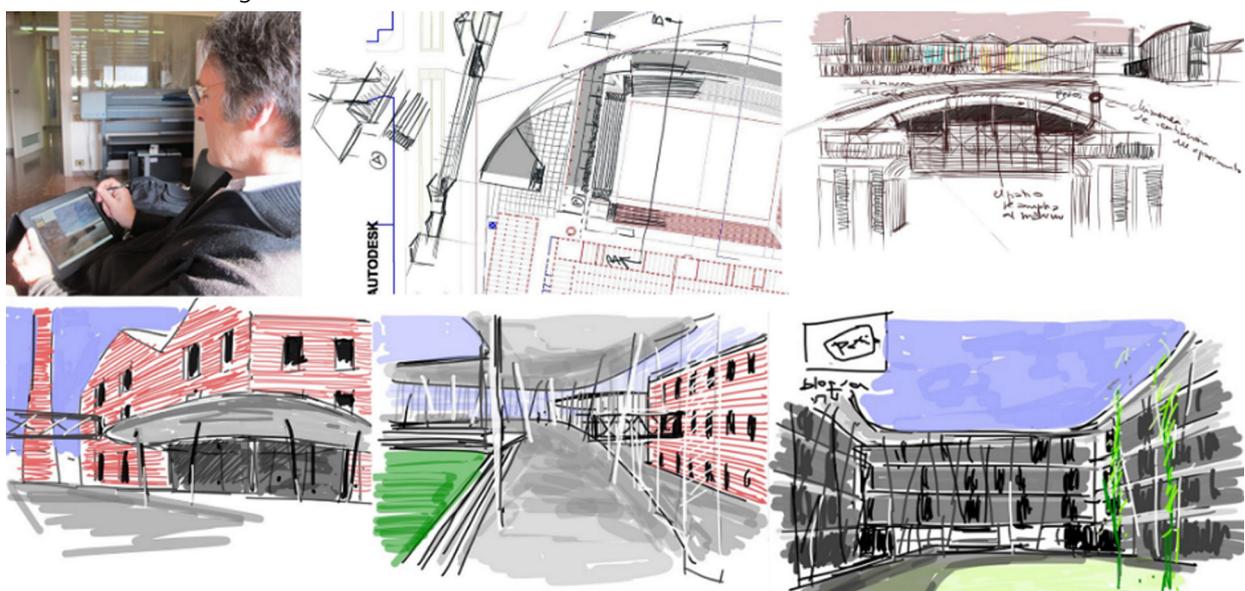

Fig. 1 Examples of Digital Sketching using mobile devices

In this direction, and based on several previous experiences in architectural teaching (Redondo

& Santana, 2010), it has been shown that this type of drawing over digital interactive boards is a suitable tool for the teaching of traditional drawing and that its use in combination with IT improves the graphics skills and the students' academic performance. Generalizing the working definition, it could be said that we are in front of a hybrid drawing technique, and could be defined as the work with files in different formats that are juxtaposed in the same representational level. Another way to define these systems would be that they are the methods through which a drawing or graphic can be generated using elements of different nature, or what is the same, strategies and methodologies where perception and geometry, art and technique, manual and mechanical are blended. In short, the artistic and technical-geometrical components are put together in as single system, not juxtaposed but sharing the same digital platform (Fig. 2).
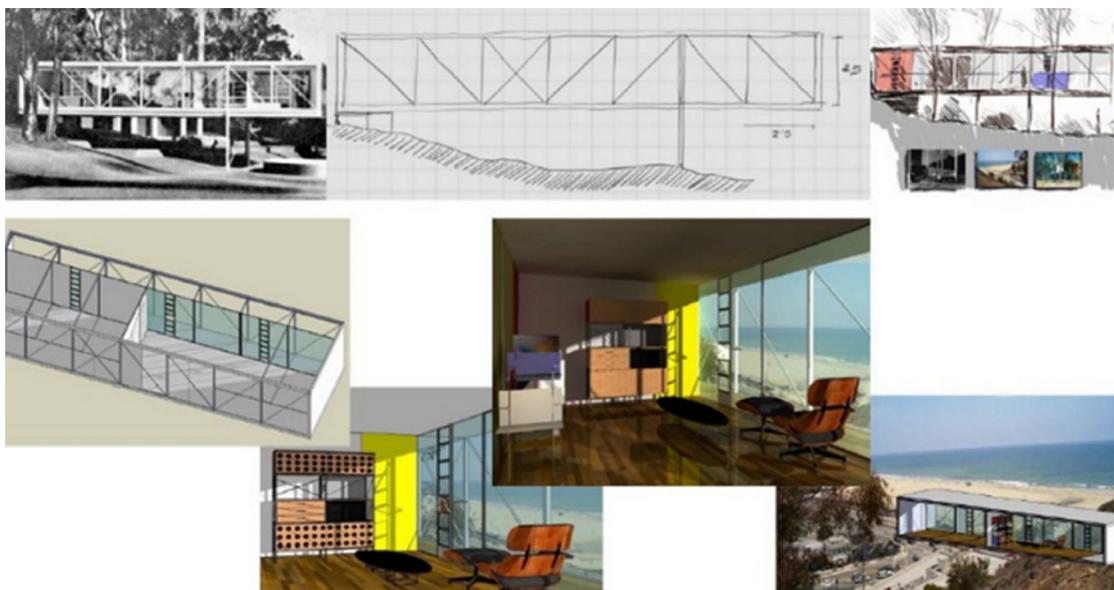

Fig. 2 Examples on Hybrid models and representation.

It is clear that hybrid approaches applied on teaching strategies, especially when related to graphical topics, can be a solution to both improve students' motivation and ease their learning process. One hybrid visual technology that is gaining attention and is being incorporated into every field is Augmented Reality (AR). Its creators (Milgram & Takemura, 1994) define AR as a VR (Virtual Reality) variation in which the user can see the real world with virtual objects mixed or superimposed upon it. Users (in our case, students and building sector professionals), can work with computer-generated objects as if they were real objects in a real environment, in real time by superimposing virtual objects onto a real environment through markers, with the capability of modifying and manipulating the scale, position, and location of virtual objects. AR technology, by providing new interaction possibilities, promotes active student participation in its own knowledge construction. This concrete superposition option between virtual models and reality makes this technology an interesting resource in any type of teaching in which improving students' spatial comprehension may be required.

3. Case study

This paper follows and develops previous works (Fonseca, Martí, Redondo, Navarro & Sánchez, 2014; Sánchez, Redondo & Fonseca, 2012), were students in the Architecture Degree were the subject of study. The basic objective of the general project is to observe potential differences between students from different degrees (Architecture and Engineering), in order to identify possible differences between the technological profile of the students as well as their level of motivation to use mobile technologies in the classroom. Also the main idea is to design new methodologies to incorporate advanced technologies in the classes, in order to: improve the academic performance of the students. The project is modeled by the "Group of Research on Technology Enhanced Learning, *GRETEL*" of La Salle Campus Barcelona, Ramon Llull University in collaboration with the "Group of Innovation and Educational Logistics in Architecture, GILDA" of Universidad Politécnica de Catalunya-Barcelona Tech. The study has been done during the 2012-2015 academic years with students in their first and second year of Building Engineering, Architecture, Civil Engineering and Multimedia degrees.

The experimental framework will be completed in the courses "Informatics Tools I & II" a six-ECTS-credit courses (*European Credit Transfer System*), that are taught semi-annually (I in the first year and II in the second year of the degrees). Both courses consists of 4 h of lectures, spread over 2 weekly sessions of 2 hours each, and an additional 3 hours of practical sessions. Weekly, the students have 1 hour of personal tutorials to address their doubts and solve practical problems. The basic objective of the courses are to provide students with basic skills in complex modelling interpretation and reproduction in both 2D and 3D. The secondary objective of the courses is to enable students to represent 3D models with different technologies and applications, as well as to explore methods of interactive visualization, primarily through the publication of personal blogs and the display of models with AR at the end of the course. The main topics of the subjects are:

- "Informatics Tools I": 2D drawing, 3D basic drawing, personal Blog updating with 2D and 3D files, basic 3D interaction using DWFx files (native 3D interactive format using AutoCAD®), and AR visualization using AR-Media®.
- "Informatics Tools II": 3D complex drawing using Revit®, Photoshop® and Illustrator® for panel composition, 3DMax® for illumination, apply textures & materials, and finally advanced visualization with AR and VR (*Virtual Reality*) using Lumion® (for render), Sketchfab® (for uploading the models to Internet), and Unity® (for AR and VR displaying).

To achieve the most optimal integration of the student, both courses start at a basic level in all concepts to allow the representation of any type of 3D complex models, based on the requirements

of building engineering contents and representations, architectural and civil engineering analysis, and the fundamentals of the projects required during the first two years of the degree program. Along the first subject, the methodological proposal focuses on both traditional and new techniques for enabling the publication and interactive visualization of 2D/3D models. In the second subject, the proposal focuses on the interaction and use of different applications to improve the 3D interactive presentation of complex models (see Fig. 3).
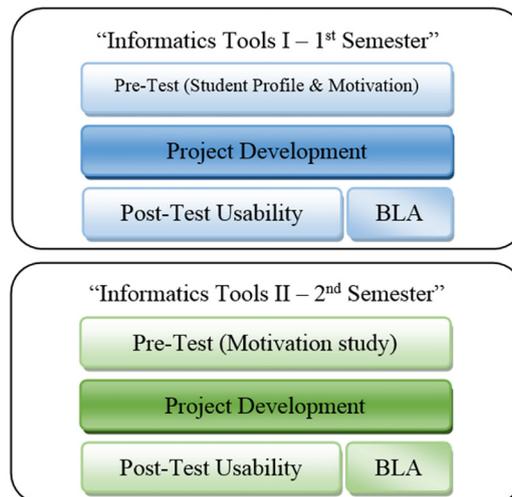

Fig. 3 Basic description of phases and student evaluation proposed.

3.1. Pre-Test: Student Profile and Motivation assessment

Based on the theoretical study, we designed two tests, with the first focusing on evaluating the IT and motivational profile of the student and the second one designed to assess the implementation of AR technology in building engineering education. In the survey design, to model the response of implementing new technologies in university teaching resources, there are prominent surveys, based on user profile, which focuses on the efficiency and effectiveness of the course, and on the level of satisfaction and student preferences (Martín-Gutiérrez, 2010).

The most common parameters that we must consider in evaluating a new approach in teaching technology are the degree of knowledge of new technologies, the use made of social networks, computer known applications, and knowledge of the theoretical content of the course under the program. In our case we have focused on the application of augmented reality to improve teaching, the work is documented in all applications and modes of implementation (Kaufmann & Dünser, 2007; Green, Chase, Chen & Billingshurst, 2008; Seokhoee, Hyeongseop & Gerard, 2006).

3.2. Post-Test: Quantitative usability assessment

A common mistake is to simplify these studies to the concept of "usability". We could understand it as the interaction of a physical or virtual device with a user and his basic human capabilities

(Nielsen, 1994). Therefore, we can state the difficulty in establishing proper ways and adapt the study to test, measure, evaluate and compare measurable results that depend on the user experience. These processes require defining methods, metrics, processes and tools to measure how to fit each experiment. In the teaching framework, the type of test to use is usually the main objective to determine usability of new learning processes of the training project. This approach means that the type of questions should be directed to the teaching methodology and not the project itself, since the project evaluation is carried out with specific questionnaires related to it.

The ISO 9241-11 standard provides the directives related to the usability of a product and that's what has been taken as a model for this work. This standard defines the concept of usability as the measurement of the capability of products 'users for working efficiently in an enjoyable way. Bevan (1999) according to the ISO standard, defines usability's components: Effectiveness (E1): a product is effective according to the accuracy degree of performed tasks and the accomplishments of the aims it has been designed to fulfil; Efficiency (E2): a product is efficient according to the speed of the tasks performed and Satisfaction (S1): it's the user's freedom for showing his agreement or disagreement with product's use as well as his attitudes towards it.

The questionnaire has been designed aiming to collect data referred to these components taking Nielsen´s Heuristic Evaluation & Nielsen´s Attributes of Usability (Nielsen, 1993), Perceived Usefulness and Ease of Use (Davis, 1989), and Usability Satisfaction Questionnaires (Lewis, 1995) as a references. The questions have been created using a 5 points Likert's scale.

3.2. Post-Test: Quantitative usability assessment

Qualitative methods are commonly employed in usability studies and, inspired by experimental psychology and the hypothetical-deductive paradigm, employed samples of users who are relatively limited. Nevertheless, the Socratic paradigm from postmodern psychology is also applicable and useful in these studies of usability because it targets details related to the UX with high reliability and uncovers subtle information about the product or technology studied (Pifarré & Tomico, 2007).

This psychological model defends the subjective treatment of the user, unlike the objective hypothetical-deductive model (Guidano, 1989). Starting from Socratic paradigm basis, the BLA system (Bipolar Laddering) has been designed. BLA method could be defined as a psychological exploration technique, which points out the key factors of user experience. The main goal of this system is to ascertain which concrete characteristic of the product entails users' frustration, confidence or gratitude (between many others). BLA method works on positive and negative poles to define the strengths and weaknesses of the product. Once the element is obtained the laddering

technique is going to be applied to define the relevant details of the product. The object of a laddering interview is to uncover how product attributes, usage consequences, and personal values are linked in a person's mind. BLA performing consists in three steps: Elicitation of the elements, marking of elements, elements definition.

4. Main Results

A total of 35 students participated in the study of the last year (17 females and 18 males, mean age = 19.31 years, standard deviation (SD) = 2.01). The results obtained from the student profile test allow us for a first approximation of whether they are ready to use mobile technology and ubiquitous Internet connections for the publication of and interaction with architectural content. Additionally, student perceptions of the system used in the 2D process and the potentiality of RA will be compared with the second test to get a clear indication of the evolution of student perceptions of, motivation toward, and satisfaction with the proposed methods. We can highlight the following results regarding the user profile and student motivation test as can be seen in Fig. 4:
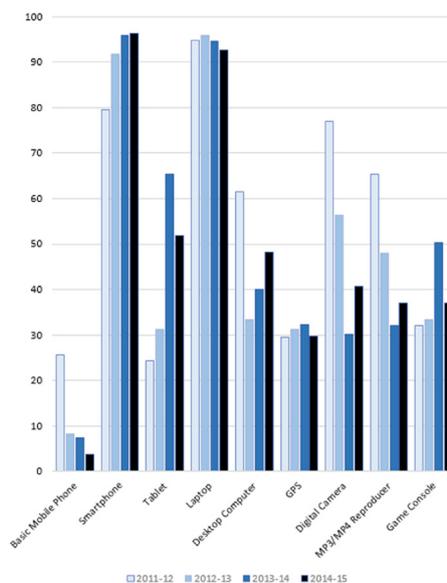

Fig. 4 Student technologies.

- Clear "concentration" of technologies in complex devices is taking place, especially regarding those whose functions has been incorporated into mobile devices such as cameras, audio and video playing capabilities.
- A significant increase in the number of students with mobile devices is identified, of whom almost everyone has a smartphone. This increase is directly related to the previous academic years were the increment of the use of mobile devices for all kinds of purposes (Fig. 5), but in the last year we can observe a decrement in the two main points related with our proposal: work and study in mobile devices.
- Almost 50% have a tablet. In this last case we can observe a clear decrease in comparison with the

previous courses. The increasing size of the smartphones screens is the cause of this situation.

- The use of desktop computers has been greatly reduced in the past years, while the level of students that have a laptop computer hovers around 100% (is maintained). However, in the last two years an increase in the use of desktop computers, data on students explained that due to the use of compact devices that often make up the majority of components in large screen shown tactile format.
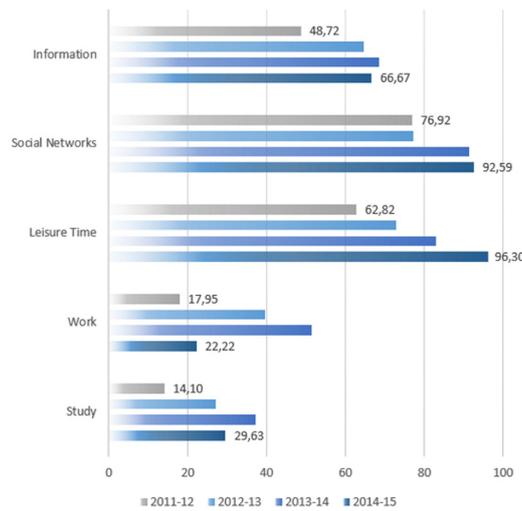

Fig. 5 Common mobile uses.

In addition to a range of supplementary data on the use of computers and mobile devices that tend to confirm our IT students familiarity and adaptation regarding these devices (frequency of use, place of connection to the Internet, most used services, etc…), they were also asked about their motivation and their initial perception on the use of different technologies and the impact it would have in their studies and practices (see Fig. 6).

As can be seen, both student motivation in the use of IT and its usefulness in the 2D representation, are very high, while the use of mobile technology, social services, and systems known as RA, place their perception of utility at more moderate levels, which in the case of seniors controlled course is

Academic Year	Motivation 13-14	14-15	2D Representation 13-14	14-15	Using Social Services 13-14	14-15	Using Mobile Devices 13-14	14-15	AR Utility 13-14	14-15	IT to impr. 2D/3D repr. 13-14	14-15	IT to pass the subject 13-14	14-15
Full Disagree	5,71	0,00	0,00	0,00	5,71	7,41	11,43	11,11	2,86	3,70	14,29	11,11	8,57	11,11
Disagree	2,86	3,70	0,00	0,00	8,57	22,22	11,43	3,70	0,00	0,00	2,86	7,41	14,29	3,70
Neutral	5,71	22,22	8,57	14,81	20,00	37,04	22,86	29,63	22,86	25,93	25,71	37,04	17,14	22,22
Agree	48,57	40,74	57,14	44,44	40,00	18,52	25,71	25,93	28,57	29,63	37,14	33,33	20,00	44,44
Full agree	37,14	33,33	34,29	33,33	25,71	7,41	28,57	18,52	45,71	25,93	20,00	7,41	40,00	11,11

Fig. 6 Common mobile uses.

clearly below the results of the previous years.

In short, the checkpoint where the student profile and motivation is evaluated, in this final year students are more skeptical about the usefulness of techniques that in most cases unknown, being a point cautious view regarding the results of previous courses.

Once the practical classes were finished, the students were asked to answer the post-test survey. The objective of this survey was to re-assess the motivation of the student regarding his/her perceived usability of the technologies used. To get this information, the concepts related to the motivations previously studied in the pre-test were asked again. Fig. 7 shows the comparison of the results for these questions, before and after the classroom practice.
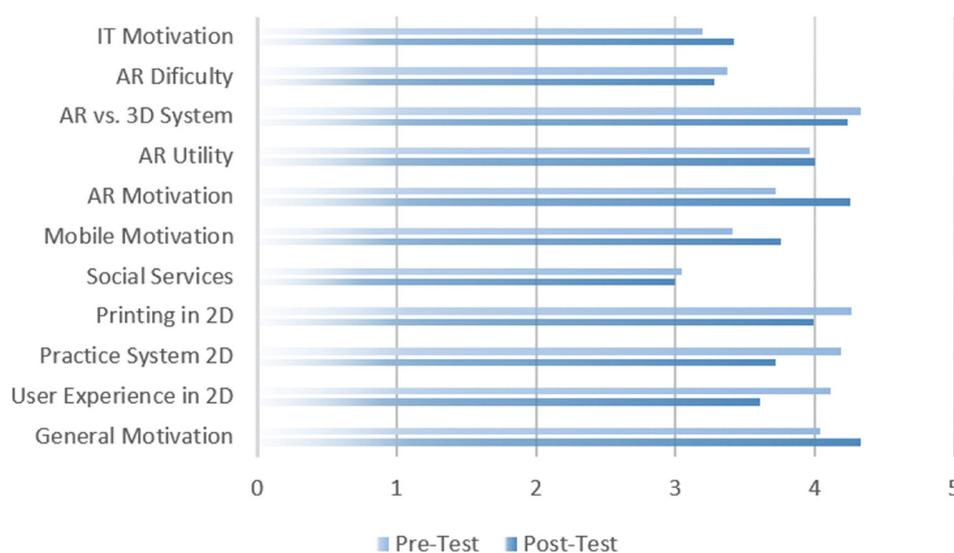

Fig. 7 Pre-test and Post-test comparision.

After the experience the students consider that the 2D system can be improved (lower rates post-practices), and using IT like AR, help the students to improve their 3D work, partly because it is a system which is easier to use than expected. However doubts remain on the usefulness of these systems to their projects.

Table 1 shows the students' main perceptions, including their evaluation of the course material, the proposed methodology, perceived usefulness, and level of satisfaction. The average responses related to effectiveness (E1), efficiency (E2), and satisfaction (S1) are very similar to previous (Fonseca, Villagrasa, Valls, Redondo, Climent & Vicent, 2014).

These results (with a general average of 3.76/5) allows us to state a priori a positive result of our teaching proposal, hypothesis currently under study and that can only be confirmed by the analysis of the BLA data.

Finally, we have gathered 12 BLA interviews (conducted randomly among the students of the subject).

VARIABLES	2013-14		2014-15	
Material/Contents	*Av.*	*SD*	*Av.*	*SD*
(E1) The material of the lecture has a good presentation	4.53	1.32	4.00	1.15
(E1) The structure of the sessions/exercises are appropiate	3.92	0.98	3.872	1.02
(E1) It is easy to manipulate the exercises porposed	3.67	1.21	3.28	1.00
(E1) Models are suitable to manipulate virtual elements	4.01	0.97	3.1001	0.65
(E2) The number of exercises are related with time proposed	3.55	1.53	3.65	1.24
(E2) It have been possible to solve the exercises presented	4.58	0.64	3.58	0.89
(S1) Theoric classes are sufficient to know how to proceed	3.35	1.25	3.52	1.08
Application of AR technology				
(E2) The application of AR has been stable (no crashes)	3.47	1.43	3.52	0.65
(E2) Familiarity with the gestures has been easy	4.35	0.89	4.25	0.95
(E2) No delay in the visualization/manipulation of models	4.25	1.35	4.21	0.75
(S1) Level of definition of 3D virtual models	4.18	1.21	3.76	1.15
(S1) AR rating about improving 3D complex models	3.87	0.99	3.76	0.99
(S1) Viewing 3D models with AR applications	4.48	1.58	3.71	1.15
(S1) Rating about how AR work with 3D complex models	3.99	1.05	3.89	0.45
(S1) Rating about usability of AR syst. and methodologies	3.85	1.29	3.91	1.11

Table. 1.- Post-test usability values studied (MAX: 5, MIN: 1)

We have polarized the elements based on two criteria:

- Positive (Px) / Negative (Nx): The student must differentiate the elements perceived as strong points of the experience that helped them to improve the type of work proposed as are useful, satisfactory, or simply functional aesthetic (see Table 2), in front of the negative aspects that did not facilitate work or simply need to be modified to be satisfactory or useful (see Table 3).
- Common Elements (xC) / Particular (xP): Finally, we separated the positive and negative elements that were repeated in the students' answers (common elements) and the responses that were only given by one of the students (particular elements).

In Tables 2 and 3, we show the main results (common elements) and in Table 4, the main solutions and improvements for positive and negative common elements cited.

	Description	Av. Score (Av)	Mention Index (MI)
1PC	Organization of the subject	9.66	75%
2PC	Practice Method	8.85	58%
3PC	AR use	8.71	58%
4PC	Faculty (quality/availability)	9.00	50%
5PC	Utility	9.00	16%
6PC	Printed exercises	8.50	16%
7PC	Exam models	8.50	16%
8PC	Continuous monitoring	8.50	16%
9PC	Constant exams	8,00	16%

Table. 2.- Positive Common (PC) elements

	Description	Av. Score	Mention Index
1NC	Problems with software & hardware	3.57	58%
2NC	Time between deliveries	4.60	42%
3NC	Work in groups (2 students)	4.33	25%
4NC	Duration of the subject	3.00	16%
5NC	Deliveries using Moodle system	5.50	16%
6NC	2D Printing	5.00	16%
7NC	Repeat more the main concepts	5.50	16%

Table. 3. - Negative Common (NC) elements

	Description	Mention Index
CI-P	More tips and tricks (explanation)	92%
CI-P	More time	58%
CI-P	Shorter practices and works	42%
CI-P	More applications	25%
CI-P	More documentation	16%
CI-N	More tips and tricks (explanation)	75%
CI-N	More time	50%
CI-N	Improve hard and software	42%
CI-N	Improve time between deliveries	16%
CI-N	More documentation	16%
CI-N	More digital reviews	16%
CI-N	Individual work	16%

Table. 4.- Common Improvements (CI) for both positive (P), and negative (N) elements

5. Discussion

In recent years, largely due to the adaptation of curricula to apply the rules mandated in the EHEA (European Higher Education Area), different IT have been incorporated in all educational levels. The purpose of these teaching practices is to provide students with the skills and competencies outlined in their specific academic plans and subjects in a quick and with a high degree of autonomy way. The adaptation of contents and applications in this area has emerged as an interesting field of study to assess the degree of motivation, satisfaction and usability of students. For this reason, is critical to assess the chances of success or failure of these practices.

A final scale, in order to begin with the results discussion, which is important to be considered in the study to provide clear information about the usefulness of the proposed methodology is the final marks of the students, centered in the second phase of the subject (when the students work with 3D models and advanced technologies for visualization like AR) with our methodology was implemented. As can be observed (Fig. 8), the introduction of the EHEA system in the degree of Construction Engineering resulted in a decline in academic performance on the subject taught by our team, specifically in this phase. We can blame this decrease (clearly noticeable in the 2010-11 and 2011-12 academic years) to the lack of adaptation of the contents and the pace of the classes to the new framework.
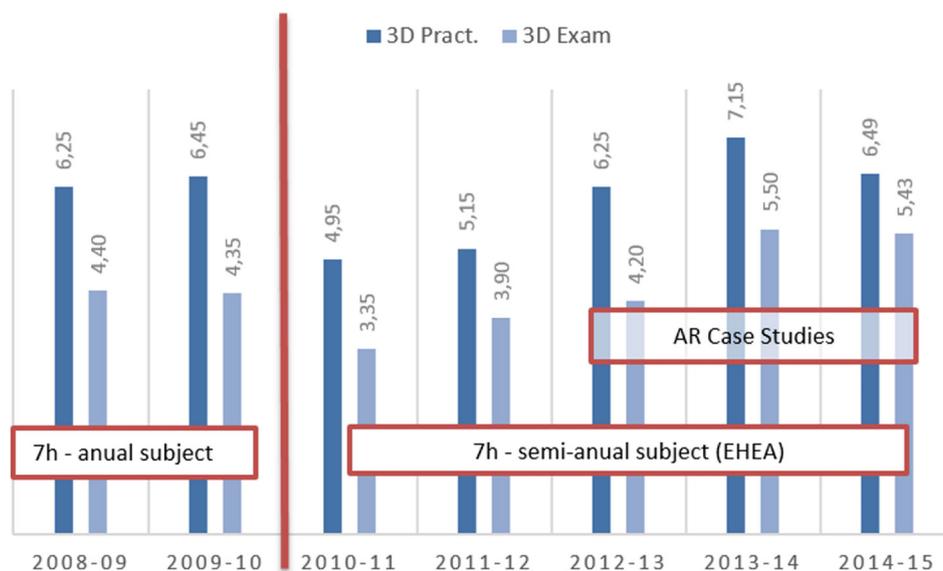

Fig. 8 3D grades related with the second part of the subject with practice and exams in

The results should be interpreted as a whole. Initially we can say that due to the experiments academic results have been consolidated within a proper range, especially comparing the results of 2012. The practices are within the excellent range of grades, even having a smaller time commitment in class

and doing a more thorough job regarding pre-EHEA period. Moreover, due to continuous monitoring, students have improved their exams progressively in recent years, which is helping to raise the general record.

Focusing on the results of this last year, a decrease is observed in the practice grade of around 10% over the same system implemented in the previous year. While this information could be discussed independently and assimilated to the difference of groups and individuals, other data found in the study that might relate these results to the degree of initial student motivation. As shown in Fig. 6, the comparative degree of initial motivation between the last two years show a degree of motivation or perception to tech lower than to the previous group. Of the seven categories studied, in all the extent of more positive perception (full Agree) has declined (values marked in yellow), and the next positive value, a general reduction occurs, except for the assessment of IT will help pass the course (with one of the highest climbing above 100%, from 20% in 2013-14 to 44.44 today increments). That caution is confirmed pronounced by increasing neutral responses in all categories, and comprehensively reduced negative perceptions, reaffirming the position of doubt or neutrality in the current group.

Analyzing survey responses usability once the practical experience an overall decline observed values studied. The responses compared to students in the last two academic years (where the difficulty level model and deliveries were comparable in both complexity and objectives and time), show a clear decline in overall student response (from an overall average of 4.01 with a standard deviation of 1.17, a global in this course of 3.73, with a deviation of 0.95).For a better comparison we have used the analysis of variance (ANOVA) using a threshold of 0.05, getting significant differences between the students usability questionaries' of the two last academic years: $F = 2.42$, $p = 0.015$.

Separating the structure and contents of the course on one side and the technical aspects related to the use of RA, the comparative results again show us a significant difference between the two groups in terms of working with AR ($F: 1.95$, $p = 0.04$), but not in terms of overall assessment of the course where a $F: 1.66$, $p = 0.07$, which exceeds the threshold of 0.05 defined.

Since the BLA study does not reflect mismatches comments on previous studies in the framework described, it is shown that the relationship affects the degree of motivation and student involvement in the matter (being reflected academic results).

6. Conclusions

Due to the results reported and based on the discussions held, we can say that college students investigated programs are now able to use new mobile technology display systems. This training is

linked to the possession and use experience as digital natives have, and secondly the interest in using technologies that may be of benefit to both educational and occupational level.

The distinguishing factor of a presentation of a project or practice, in the world of architecture and engineering, may be how to view it. In this sense, work with technologies that are adapted for use in mobile devices are not only attractive to the general user, it can be incorporated effectively in education. The hybrid technologies capable of superimposing virtual information in photos, videos or image that instantly captures real world, allow better spatial compression for both beginners and experienced, making the user experience in a motivating and satisfying exercise.

The present work has demonstrated the direct relationship between the motivation of use, and the results of the user experience, and how this relationship affects the degree of progress in the use of a particular technology. The results have shown that the use of IT, and specifically the AR in teaching, improving student space capabilities, especially depending on the motivation of this. In order to refine the proposed systems are currently being implemented similar exercises in up to four different subjects in grades Architecture, Building Engineering and Multimedia. In order to improve the implementation and monitoring system of students, now also being designed to apply for next year 2015-2016, new strategies combining mobile hybrid visualization approaches that gamificated allow both the system self-assessment of the learning process of students.

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8. References

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