Using Augmented Reality and Education Platform in Architectural Visualization

Evaluation of Usability and Student's level of Sastisfaction

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Abstract - **In this paper we analyze the results of the implementation of new technologies in the framework of education related to the visualization of architectural projects. On the basis of the evaluation of the technological profile of students, we propose the use of various augmented reality systems for viewing different projects in the degree of Architecture with mobile devices. The main objective is to assess whether the proposed methodology improves the student learning process and thus generates a satisfactory response.**

Keywords: Augmented Reality, User Studies, Education, Architecture, Display.

I. INTRODUCTION

The improvement of teaching is a field under constant review and evolution, and, as with other areas such as communication or entertainment, is not exempt from being linked to technological developments. Technological developments continuously affect how society relates, communicates, entertains and learns.

The internet, social networks, Smartphones, and last generation tablets are just some of the devices or systems that are changing the way people view and interact with their environment. Whether for leisure time, to solve work tasks, or simply to communicate, these systems have changed society, especially in developed countries.

Based on the above statement, teaching and educational processes cannot remain stuck in the past. The new European Educational Space advocates new collaborative teaching models to generate greater capacity for self-learning on the part of the student, avoiding as far as possible the classic "master class" format. But these ideals are difficult to implement, as much of the faculty were themselves educated in a pre-technological time, which accentuates the gap between teachers and students, also called "digital natives" [1], who have since birth lived with all kinds of technologies both at home and at school.

In this paper we analyze the results of an educational proposal focused on the use of mobile devices for students (phones or tablets) in the 3D visualization of architectural projects through Augmented Reality (AR) and linking information related to them by QR codes (Quick Response codes).

The main objective of the study is to assess the degree of satisfaction and students' adaptation to the use of these technologies in their education and for its technological edge. We work with the initial hypothesis that using friendly technology (the term "user friendly" [2]) provides additional interest in the subject, streamlining and improving the understanding of the issues proposed. To carry out the analysis of our results and assess how well suited these measures are to our objectives, we reviewed previous methodologies [3], which we have adapted to the approach of our research, in order to obtain statistically significant results.

II. USER STUDIES

In the experimentation and research of scientific hypotheses based on the user's response, a fundamental aspect is the proper design and use of the "test user" or "survey profile" that allows the extraction of data to study. A common mistake is to simplify these studies to the concept of "usability" by way of a definition that links usability or interaction of a physical or virtual device with a user and his/her basic human capabilities [4]. Therefore, we can state the difficulty in establishing proper ways to test, measure, evaluate and compare measurable results on the user experience. These processes require defining methods, metrics, processes and tools to measure to fit each experiment [5].

These concepts are taken into account systematically in the professional field of user studies, accessibility, or usability of any software application or hardware device, often neglected when evaluating the response of a student to a particular survey result of any project or research work. A classic mistake is to prepare questions to corroborate the hypothesis of the study regardless of whether the design meets certain minimum formal requirements for survey.

If we focus on the teaching field, the main objective of most tests is assessing the 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 to the project itself, since the project evaluation is carried out with specific questionnaires related to it. In this way, and depending on the training method and the results, it will be possible to reflect and question the initial hypothesis and review a more effective implementation of how teaching methods can incorporate new technologies favorably.

In the survey design, to model the response of implementing a technology in university teaching based on the user profile, the best type is deemed to be a survey focusing on the measurement of the efficiency and effectiveness of the course, and the level of satisfaction and student preferences [6].

The most common parameters that we must consider in evaluating a new approach and technology education, taking into account the student profile, are the degree of knowledge of new technologies, the use of social networks, computer applications, devices with which they are familiar, and knowledge of the theoretical content of the course under the program. In our case we have focused on the use of AR to improve teaching, on the other well documented in all applications and modes of implementation [7] [8] [9] [10].

A. Avoiding a classic mistake: the selection of the sample

It is easy to find studies in which results are extrapolated to a general population from a small sample, being a sensitive issue and often subject to errors that are typically not taken into account although they affect the evaluations obtained [11].

When research is conducted in the university framework is used systematically students related to the thematic topic of a particular learning environment, close to the researcher or the group that publishes the work. We find a great number of references of previous works that show this affirmation, being especially remarkable in psychological studies [12] [13], but also with examples as diverse as religious studies [14], and almost certainly some of our own studies.

These samples are usually comprised of young people between the ages of 18 and 28 (university period), usually compensated by sex (but not always, as in most cases the degree is not the same in this respect: in an engineering degree most students are men, whereas in psychology most would be women), with similar origin (country or region), and a social stratum also usually homogeneous (as we may say that access to a particular university is often conditional on academic and economic aspects that differentiate students within or among schools).

These features should be taken into account in the study and analysis of any technology implementation in education, since it will not make that same action in an environment with students from middle/high class in a geographical area with capacity to acquire and use these devices or applications instead of making the same technology implementation project in a geographic area or environment where students have failed to have that "prior experience", generating what is defined as the digital divide. In line with this, with the aim of defining study samples as possible and valid offset, we find several initiatives [15] [16] focusing on the selection of samples for university studies.

In the case of technology implementation studies in university education (present case), the choice is easier than in the case of more general studies, such as medical tests, psychological tests or tests related to the world of communication. For our work, in which the objective is to evaluate students’ adaptation to the inclusion of certain technology, it is important to evaluate the degree of previous experience in the use of technologies prior to the execution of a survey, more than the influence of age, sex or origin.

As in any general research, the design of the study sample is vital to avoid making errors of judgment. For example, it would not be valid to use only college students, but we should design a population-wide range of age, gender, culture or studies for which we are interested in obtaining correct conclusions. Cultural differences [17] [18], age [19] [20] or gender [21] [22], besides being well documented, also affect personal aspects and thus their response before of any stimulus to be evaluated (from verbal ability, personality, sexuality, ability to take risks and even in their technical skills [23]).

B. Augmented Reality and bidimensional codes

The appearance, popularity and increasingly easy access for users in general to mobile phones with camera and multimedia features such as internet access, and more recently the media tablets, regardless of their operating system, has generated a global explosion of the use of two-dimensional codes in any social field. It has gone from industrial use in the storage and labeling for general use in any field, especially in advertising and entertainment, as we see in the Figure 1:

Figure 1. - Examples of use of QR codes.

These graphics are called QR codes (Quick Response Codes) or BIDI codes (BIDimensional) and the main advantages of these over traditional bar codes (see Fig. 2) is their ability to store more information of various kinds, anti-errors systems (Fig. 3), easy generation (Fig. 4), and multiple viewing options, printing and personalization.

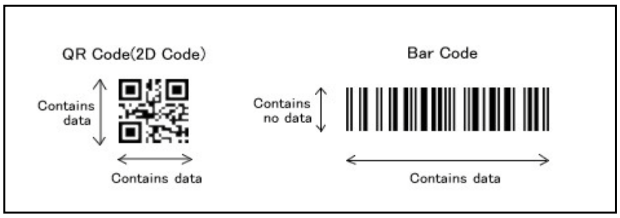

Figure 2. - Comparison between QR code and barcode [24].

		QR Code	PDF417	DataMatrix	Maxi Code
Developer(country)		DENSO(Japan)	Symbol Technologies (USA)	RVSI Acuity CiMatrix (USA)	UPS (USA)
Type		Matrix	Stacked Bar Code	Matrix	Matrix
Data capacity	Numeric	7,089	2,710	3,116	138
	Alphanumeric	4,296	1,850	2,355	93
	Binary	2,953	1,018	1,556	
	Kanji	1,817	554	778	
Main features		Large capacity, small printout size High speed scan	Large capacity	Small printout size	High speed scan
Main usages		All categories	OA	FA	Logistics
Standardization		AIM International JIS ISO	AIM International ISO	AIM International ISO	AIM International ISO

Figure 3. - Features BIDI codes [24].

Figure 4. - Example of a QR code generation [25]

A variation of the QR code is used by AR programs. The "marks" are two-dimensional codes, usually of rather simple configuration. Through visual scanning with a portable camera and subsequent interpretation by a particular program, it interprets the mark previously stored on the system and locates a 2D or 3D model, along with any type of information (also previously stored in the system) above it, as we see in the figure below:

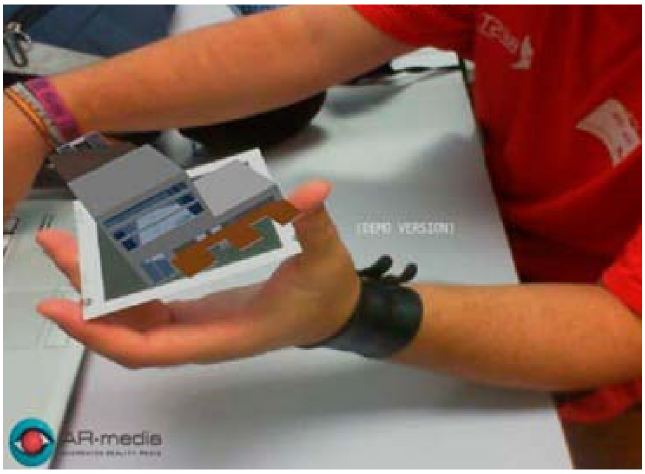

Figure 5. - Viewing a 3D architectural model using the AR-media program and marked accordingly.

In recent years, many studies have demonstrated the potential of this technology in such diverse fields as medicine [26], maintenance and assembly [27], tourism [28] [29], museums, [30] [31], or advertising and marketing, where companies see AR as a way to differentiate themselves from competitors by giving the user the ability to access stunning visual experience [32].

In some fields such as archeology and historical heritage, it has been used to display virtual reconstructions, test hypotheses, or explain a historical fact as a result of research [33].

In the field of construction, engineering, and architecture, some authors suggest that the introduction of AR is feasible in different areas such as design, excavation, staking, inspection, coordination, or supervision of tasks [34]. Specifically, in the field of architecture and urbanism AR can be used to predict the impact of construction on the landscape [35]. Also, in the rehabilitation of buildings, it has been tested as a tool for viewing via mobile devices, at 1:1 scale, the final appearance of the work, changing materials, colors and textures [36].

III. IMPLEMENTATION AND RESULTS

The project has been modeled by the Group of CAD/BIM of Department of Architecture La Salle, Barcelona Campus, and was implemented in the academic year 2011-2012 in the course of the third year of the degree of Architecture, Representation Systems, held in Architecture La Salle Tarragona Campus.

To carry out the project described in this article, we defined a series of phases and subsequent analysis results in order to check the hypotheses. The phases are described in the following sections:

A. Definition of the working hypotheses

The first aspect to evaluate is the technological profile of the students. A priori, these are regular users of mobile phones, social networks and internet, and we need to know the degree of consumption/use of them, so that we can analyze the implications that such use entails.

A second aspect to evaluate linked to the profile of students is the degree of prior knowledge of the specific technology of AR, the degree of interest that arises whether such technology is known to them or not, and what type of use the student thinks that AR could be in the study of Architecture. The relationship between the two previous hypotheses, and the relation to the specific use of AR in the exercises, allow us to assess their use and degree of satisfaction that comes prior to modification of the perception of students.

Specifically, to evaluate the adaptation of students to the use of AR, we will evaluate the degree of satisfaction on the course structure, content used and difficulty of carrying out the work ordered. Finally, we will assess whether the student considers the use of AR system displaying architectural design interesting not only in the specific case of this subject but also in their future work and which device is more appropriate to work with this technology.

B. *Design Survey Methodology*

The survey is a questionnaire provided to participants in paper format. Questions of effectiveness and efficiency have been created using a Likert scale. The assigned value indicates the degree of agreement or disagreement on the question in a 5-point scale, so that the questionnaire is answered accurately assessing the degree of agreement on the statements [37].

The Likert scale is the most frequently used in the investigation of the mass media, where each option is valued and each respondent's responses are summed to obtain a single score on a topic [38]. It consists of a set of items presented as statements or judgments, with which respondents are asked to specify their degree of agreement by choosing one of the five criteria listed in the following table:

TABLE I. Likert Scale

Value	Equivalency
1	Totally disagree
2	Disagree
3	Neutral
4	Agree
5	Totally agree

The final design of the initial survey for the user profile, as the final course evaluation and technology, have been published and can be consulted at the 7th Iberian Conference on Systems and Information Technology, Madrid, 2012 [3].

C. *Chronology of work*

The type of training aims to develop Architecture students' skills in presenting their projects with new tools to apply the technology of AR. The training program is integrated into a subject in which students have previous experience with traditional techniques (digital imaging, 3D modeling and models). Against this background, a comparison between two methods of representation may be feasible upon completion of the project.

The working group consists of nine students and a professor of Architecture. The class features desktop computers, although the project exercises are performed with the laptops of the students themselves and a high definition webcam.

The project is conducted in two sessions of five hours. These sessions are spread over two years each, making a total of four practices. These consist of a theoretical introduction to the practice and methodology. In each practice students must submit the results to the whole class for discussion.The design of the surveys was conducted throughout 2011, and the data shown in this article were collected from the exercises conducted in the first half of the 2011-12 academic year (September to February).

D. *Results*

To understand the results and graphs attached in this section, we set the horizontal axis as the degree of valuation for each response: 1 (lowest rating) to 5 (highest rating), according to Table 1. In the vertical axis are the number of responses for each question, which have been colored, coded and grouped according to the theme of each figure.

The results of the survey at the beginning of the course allow us to approximate the technological profile of the students and draw the first data that reflect a high interest (approximately 75% of the class) in technology in general. All of the students (100%) connect online at home and in the faculty, mainly using laptops and mobile devices. The connection type used is WI-FI (90%), combined with ADSL type (75%). Only 25% of the students work with 3G internet connections with mobile devices.

The most used services are mainly e-mail (100%), browsers and download (75%), and university queries related to architecture (100%). The use of chat rooms, blogs, news or query is placed in a smaller frequency of use (over 25%). In conclusion the students are interested in using technology but they not have previously experience with AR (see Figure 5):

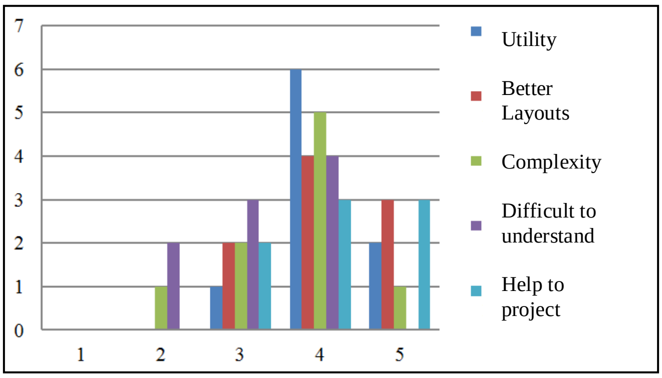

Figure 5.- Perception of utility of Augmented Reality

Students reflect an initial view that can be summarized as indicating that AR is a complex technology to implement and for the end-user, but one that can be useful in presenting their projects.

Once the teaching experience has been conducted, students were asked more specifically for their ratings on various technical points related to the use of AR in carrying out the work requested. In Figure 6, we can see the results of the evaluation of the support material used:

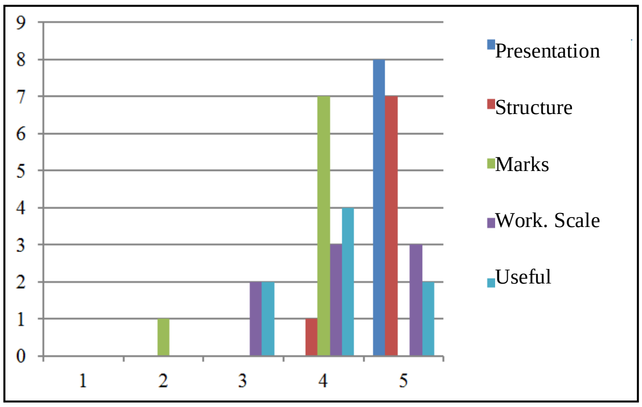

Figure 6. - Results of the support material.

The response to the interaction of students with special equipment for the project and its visualization by AR is grouped in the following Figure 7:

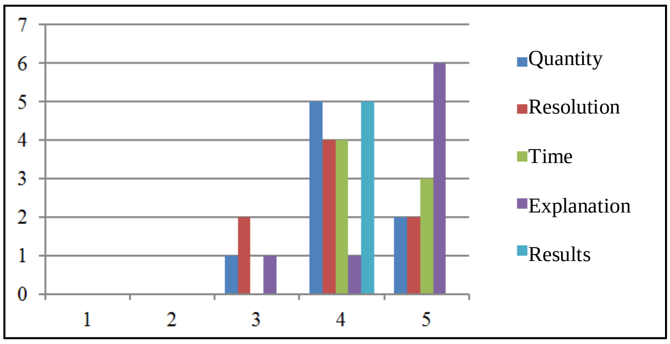

Figure 7. - Results – Material

As we can see again, highly satisfactory results are obtained in this interaction (most answers were 4 or 5 according to Table 1), and it is possibly the quality (resolution) and number of display options available which could be most affected with a lower values.

Asked generically about the use of AR in the visualization of architectural results (Figure 8), the results are:

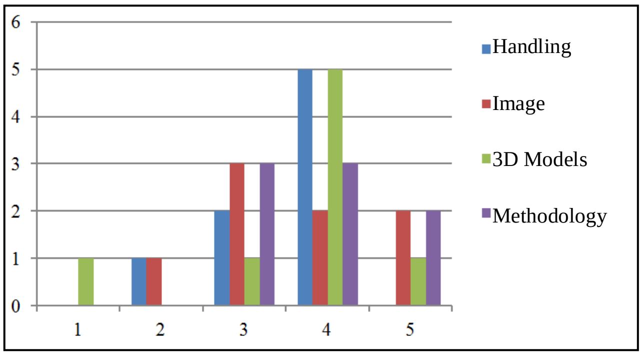

Figure 8. - Results of Technology RA

The results reflect the worst ratings in terms of image quality obtained and the difficulty of learning this type of technology. This last value is close to a neutral value and reflects the need to improve on these teaching methodologies, and also with the visualization of complex 3D models (typology of objects in which 80% of the students reflect the need to improve ease of use). After a closer look at the results of the surveys and the devices used, we attribute the differences obtained to two main aspects: the different standards between laptops and mobile phones (devices used), and previous experience of students in the use of such technology, in most cases this being their first experience.

IV. CONCLUSIONS AND DISCUSSION

Based on the results and the initial aim of the study (to evaluate if the use of technology with which students are familiar in a teaching environment provides them a satisfactory value in their education), we can conclude that this hypothesis is not entirely conclusive. On the one side, they welcome the use of mobile phones, laptops, and tablets, but in most cases the first experience of using AR techniques entails usability difficulty that affect their level of satisfaction.

Students have valued their experience as very positive, highlighting both support materials for conducting the exercises, but have also encountered difficulties in the highlights of the display such as resolution, quality of the models, and working interactively with 3D projects.

Finally, we note that the experience has generated a growing interest among students to continue using and expanding their knowledge in the use of AR for visualization and interaction with their architectural projects. This aspect allows us to say that interactive technologies and mobile display field, especially related augmented reality, should replace or at least be made available in parallel with the traditional representation systems such as printed panels and models.

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