Student motivation assessment using and learning virtual and gamified urban environments

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ABSTRACT

The configuration of urban projects using ICTs is an essential aspect in the education of the future architect. The student must know the technologies that will facilitate their development and presentation, as well as the needs of the citizen and the expectations of the project. The present article focuses on evaluating both the initial and final intrinsic motivation of the student in the process of incorporating gamified virtual reality systems for visualization and interaction in urban projects. The results reflect a significant increase in student motivation as he / she understands the use and potential of such systems in the visualization and understanding of architectural and urban space.

CCS CONCEPTS

Human-centered computing → Virtual reality • Human-centered computing → Visualization design and evaluation methods → Software and its engineering → Virtual worlds training simulations

KEYWORDS

Student motivation; virtual reality; gamification; PBL, ICT, architecture and urban education.

1 INTRODUCTION

Representation technologies are used throughout the architectural design process to bring ideas into reality, allowing communication between designers, clients, contractors and collaborators [1]. Architecture students must learn to be proficient in these technologies throughout their studies, and must reach the point where drawing and representation blend together, and drawing becomes thinking [2].

Therefore, it is necessary that students become skillful in multiple representation technologies, and that they are capable of incorporating the latest technologies into their design process in order to better communicate their proposals, and to facilitate critical reasoning on the spaces they conceive.

The emergence and popularization of information and communications technologies (ICT) is changing modern society and its educational landscape. ICT facilitates individuals' ability to learn anywhere and at any time. In fact, by using ICT, access to knowledge acquisition is not restricted to formal contexts, such as academic institutions. Computers and information technology have increased educational opportunities and have opened the way to new learning approaches. Due to this, several concepts from the collaborative learning, gamification and informal learning appeared.

Therefore, it is critical to understand whether users (the students) are receptive and aware to adapt to this new paradigm using advanced visualization methods. In this context, the aim of this paper is to investigate the perception and intrinsic motivation of higher education students of architecture degree and master related with the use of virtual and gamified systems to represent the 3D urban space.

The project presented in this article involves computing science, architectural education, and public urban policy for future cities [3, 4]. One of the innovative aspects of this project is to incorporate gaming strategies in an urban collaborative environment to enhance an initial design proposal. This approach aims to incorporate actively architecture students (as urban designers), multimedia engineering and informatics students (as multi-platform programmers), and final users. Citizens will play with virtual models and they will generate points of view that were not considered in the original proposal. This could be useful for project improvement since informal and casual perception would be incorporated to the project design. This fact would feed back into student's education, primarily oriented towards formal content so far.

2 CONTEXT

ICTs are transforming citizens' lifestyles, adding new dimensions to the concept of socialization, as well as creating new habits [5]. Bower [6] described the opportunities offered by these emerging technologies as "creating a new kind of reality, one in which physical and digital environments, media and interactions are woven together throughout our daily lives." At

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the same time, the new university students can be defined as Digital Natives [7], because they coexist and use all kinds of network technologies, various applications and all kinds of mobile devices at very early ages.
In architectural education, until recently, the use of ICT was restricted to project implementation processes, where various applications such as Computer Assisted Design (CAD) and Building Information Modeling (BIM) served merely as aids in the execution of one's work [8]. Historically, in civil and building engineering education, visualization and understanding of 3D space was typically accomplished via the classical view (physical models and drawings), in front of 3D models and using virtual specifications. This approach is changing due to a generational change and the continuous improvement and development of technology. The new systems based on VR/AR (Virtual and Augmented Reality), Geo-Referencing, and learning gamification, will gradually reduce the control imposed on the designed tasks and scheduled presentations.
Due to the potential of virtual systems, we can strengthen the spatial skills and abilities of students, while also using the essential interactive and collaborative features of these processes. Students can work with peers and teachers and participate in multi-tasking/multi-user collaborative and instant tracking [9]. The simplicity of completing the most basic models with the creation of new objects, light treatment, materials, textures, and shadows allows a dynamic workflow that is much faster to complete than physical scale models [10]. Additionally, the versatility of virtual worlds and their use in social networking allows for creation and collaboration with heterogeneous groups from all over the world, who can collaborate synchronously in different virtual spaces. Virtual worlds provide a combination of simulation tools, a sense of immersion and opportunities for communication and collaboration that have great potential for their application in education [11, 12]. However, as criticized in [13], many of the existing educative experiences in virtual worlds only replicate traditional approaches, such as recreating the classrooms.
Focused in the urban data, Gordillo [14] proposed a generic model to support a new way of visiting a city. In this approach, instead of understanding the city as a place for tourism, the students perceive it as a place for learning in which all necessary educational resources are available. The model has been conceived as a way to encourage learners to create their own educational tours, in which Learning Points Of Interest are set up to be discovered using two models—formal (conducted by a teacher) and informal outdoor mobile learning (no educator is related to the learning experience).

Gamification in Urban Projects

Merging gamification and 3D architectural models, we can find some references in the use of gamification applied to urban planning process with citizen participation: "Blockholm", a game based on Minecraft promoted by the Swedish Center for Architecture and Design. The objective of the game is based on designing an intelligent city of the future from the real cartography of the city where the topography, streets, lakes, rivers, etc. are included. "Play the City", of the Play the City Foundation implemented throughout the year 2012 in different cities in Holland, Belgium, Turkey and South Africa is based on a game similar to World of Warcraft. Other previously used strategies have been based on the use of the game "SimCity", in its different versions, in urban planning workshops, highlighting the case of Cape Town in 2013 (Fig.1):

Figure 1: Blockholm, Play the City and SimCity 3000, project examples.

All of them were worked from basic zoning proposals of general uses to large-scale digital work. They incorporate noteworthy aspects linked to informal teaching models: citizens generate series of opinions or suggestions, which help students to see different points of view; this information improves their formal knowledge, as cases were conducted outside an academic environment; and all of them are focused on the urban planning. In the current project proposal, it is important to work on both an architectonic project and urban design at the right scale that allows a larger level of detail and complexity.

Motivation assessment

Starting from a critical approach, the first question we could ask is: What do serious games contribute to these processes? There are several answers: First, the game strategies have been shown as an element of learning or interesting decision making, useful and applicable in various areas of knowledge (marketing, business, formal education, non-formal education, etc.). On the other hand, we can obtain other answers on the usefulness of serious games from current demonstrations on the contribution of a higher degree of motivation in the monitoring of the gamified contents, the increase of the participation, and of course, in the inherent dynamism they apply to such contents [10, 15].

To evaluate the motivation of an academic proposal, it is necessary to contextualize the innovation environment. Through the profile of the students, we can be quickly check whether or not they are prepared to follow the course and / or use the technologies designed. A group without access to the technologies envisaged, regardless of being highly motivated, can degenerate a failure of educational implantation, being necessary to redesign the method adapted to the possibilities of the students. By evaluating the initial levels of certain variables, the evolution obtained by the proposed method can be verified in the final phase [16].

The study of motivation is relevant and significant, both as it has been previously demonstrated [17], as well as a motivated student can improve much faster and more efficiently regardless of their initial level. This aspect, linked to the field of study (the degree of Architecture), confers a singular interest on the present work, since the studies of Architecture in Spain are linked to the more technical side of Higher Education, and further away from the artistic branch, as in other countries. For this reason, in recent years, due to the crisis in the sector [18], the increase in internationalization and the inherent unforeseen difficulty, often unknown in these studies, led to a decrease in the number of students, as well as high dropout rates. In short, it is clear that evaluating the degree of motivation and using differentiated methods that maintain a high rate of empathy between the student and the subject is fundamental to not lose vocations in the early stages of the studies.

In this field, one of the most used and validated methods for measuring motivation is the IMI (Intrinsic Motivation Inventory, [19]). The instrument assesses participants' interest/enjoyment, perceived competence, effort, value/usefulness, pressure felt and tension, and perceived choice while performing a given activity, thus yielding six subscale scores. Recently, a seventh subscale has been added to tap the experiences of relatedness, although the validity of this subscale has yet to be established. The interest/enjoyment subscale is considered the self-report measure of intrinsic motivation. Thus, although the overall questionnaire is called the Intrinsic Motivation Inventory, it is only the one subscale that assesses intrinsic motivation, per se. As a result, the interest/enjoyment subscale often has more items on it than the other subscales. The perceived choice and perceived competence concepts are theorized to be positive predictors of both self-report and behavioral measures of intrinsic motivation, and pressure/tension is theorized to be a negative predictor of intrinsic motivation. Effort is a separate variable that is relevant to some motivation questions, so it is used when it is relevant. The value/usefulness subscale is used in internalization studies [20], the idea being that people internalize and become self-regulating with respect to activities that they experience as useful or valuable for themselves. Finally, the relatedness subscale is used in studies having to do with interpersonal interactions, friendship formation, and so on.

3 THE PROJECT

Project Description

The study described in this article focuses on the description of the implementation process of gamified RV systems in architecture teaching and the perception of utility and motivation of the student in front of these proposals. The overall aim of the project is to virtually recreate urban areas of the city of Barcelona and its surroundings, in order to establish a user-friendly environment where users (students, professionals, architects and citizens of all types and ages) can interact (play) with, in order to recreate new spaces centered in pedestrian uses, instead of the present ones that do not contemplate predominantly this typology of space. The virtual three-dimensional space is also intended to have a photographic quality (i.e. maximum realism), incorporating the movements, materials, textures and even sounds of the environment.

In the current phase of creating a pilot project the tasks in progress and their distribution are: (1) Definition of the urban environment, initial proposal of uses, modeling and texturization of buildings (UPC). All this using modeling tools like 3DMax, Rhyno, Sketchup, Photoshop, etc (see example of Fig.2).

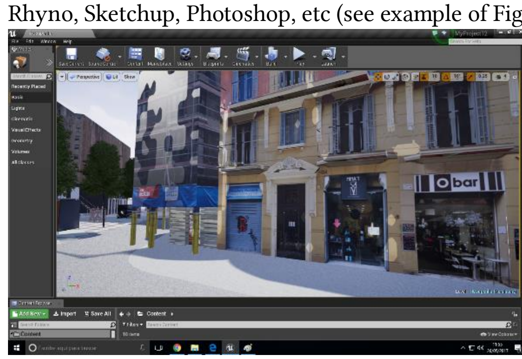

Figure 2: Integration of 3D models of buildings into Unreal environment.

Definition of game mechanics, interaction, constraints and implementation system, programming and integration of models and interface (La Salle). Unreal is being used for this process (see example in Fig. 3).

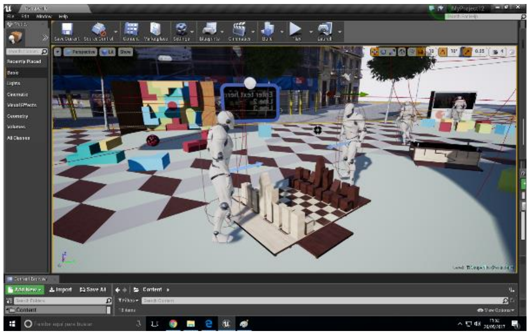

Figure 3: Inclusion of characters and programming of actions and challenges in Unreal.

Definition of metrics and analysis evaluation (La Salle). Fields of study: Subject of Multimedia Representation, Architecture degree UPC; Master of Landscaping UPC; Subject of Representation Tools II, Architecture and Technical Architecture degree La Salle.
The processes described have been carried out in the second semester of the academic year 2016-2017, being the provisional models, and waiting to obtain the results of the post-test once the course is finished.

Data Design

For the study, we used an initial questionnaire to obtain both the technological profile of the students and the degree of interest in the topics and approach of the course. For the section of the profile, we have asked for statistical data such as age, gender, place of birth, completed, ongoing studies, and possible work experience. They have also asked about the devices and access to Internet services both at the level of use / membership and frequency of use.
In a second block, we have included 18 questions divided into three blocks (see Table 1). The first one (consisting of eight questions identified as A1-A8), is focused on obtaining the student's perception of the degree of utility of technologies such as RA / RV for visualization and understanding of architectural space. The second block of three questions (G1-G3), is focused on evaluating the perception of utility of games in the understanding of space and its educational use. Finally, through seven questions (identified as IM1-IM7), we evaluated the subjective response of students referred to IMI.

Table 1. Pre-Test control variables

Question	#
3D digital visualization of architectural and urban projects is of vital importance for their understanding	A1
The use of virtual reality to visualize projects is useful for understanding	A2
The use of augmented reality to visualize projects is useful for understanding	A3
I am motivated to use AR / VR in the project presentation phase	A4
The materials, textures and lighting of a virtual scene should always be as realistic as possible	A5
Environmental sounds should be as realistic as possible	A6
The existence of ambient music satisfies me in the visualization and interaction with virtual proposals	A7
The display device (mobile, tablet, computer, glasses) greatly influences the perception of virtual quality	A8
The use of a crowded environment (with missions and achievements) is better than free navigation by virtual zones	G1
In the case of gaming systems, I am motivated more those who are single-user regarding the multi-player	G2
I consider that the use of games in educational environments provide a better understanding of the subjects	G3
I enjoy playing in virtual environments. I consider these kind of experiences very funny and entertaining	IM1
Through the 3D visualization I acquire better skills related to the architecture compared to traditional systems	IM2
I believe that the use of virtual and gamified proposals need less effort than traditional systems	IM3
The use of virtual proposals generates less tension, stress, nervousness than models based systems and panels	IM4
Do you consider that by using virtual proposals you change the way you work in the future with architectural presentations?	IM5
This type of activities (games and virtual navigation), are useful for my future and can benefit me	IM5
These systems help me interrelate with other users / partners / friends by expanding my relationships	IM7

4 RESULTS

The sample of work was a total of 75 students, 30 men and 35 women, with a mean age of 23.8 years (Typical Deviation, DT: 5.47). 56% are Spanish and the rest of multiple nationalities: 5 Norwegians, 3 Colombians, 2 French, Venezuelans, Ecuadorians, and a representative of Mexico, Italy, Austria, Argentina, Costa Rica, Bulgaria, Peru, Brazil, United States of America And Andorra. Nine of them were attending Master's level and the rest, 66, the grade level. Only 16% were alternating their studies with some type of work.
Reviewing the technological profile of devices, uses and frequencies of use (according to 5-level Likert scale where 1 is equivalent to "Never" and 5 "Very frequently"), the most commonly used device is the Smartphone (Average of 4.8), Followed by the laptop (4.5). At a greater distance we find the desktop computer and digital photo cameras (2.9), GPS (Global Position System, with a 2.7), or Tablet (2.5). Other devices such as digital video cameras, conventional phones, smart watches or control bands do not exceed 2/5.
In terms of Internet usage, Social Networks rank first (4.3), followed by searches related to Architecture (3.9), and news viewing or general information (3.7). With a 4.3 students are connected by cable / fiber optics at home, followed by the WIFI connection in public places (3.9), WIFI at home (3.4), and connections in university computers and / or work (3.3). Fixed-line Internet consumption is on average 2-3 hours a day, followed by games or video games on mobile devices (an average of 2 hours a day), which is higher than mobile Internet browsing time (less of 1h daily), or the time dedicated to video games with consoles (between 1 and 2h daily average).
These data on the technological profile of students reflect a high consumption of Internet products linked to their field of study /

work (architecture), and a predisposition to high gaming (both fixed and mobile platforms, especially in the latter case).
In Figure 4, we can see graphically the result of the study variables presented in Table 1.

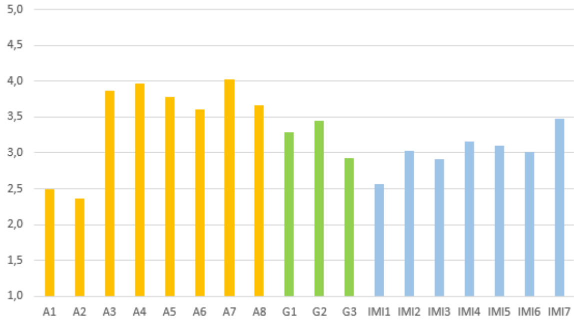

Figure 4: Study variables (Pre-test, global).

From the first block of general issues analyzed [A], the average obtained was 3.5, having weighed down the first two questions (A1: 2.5 and A2: 2.4), which correspond to the statements of how important visualization 3D architectural projects for your understanding is and in the same line, that the use of VR is useful for such understanding. Centered on the gamification block [G], the average of the three variables studied was 3.2. This value reflects an average interest, highlighting in the lower zone with a 2.9 the possible utility that students see in games in educational settings. The last block focused on IMI measurement has averaged 3.0. The best-rated aspect with a 3.5 has been the IMI-7 (the ICT systems helps the personal relationship with my colleagues), and the smaller the IMI-1 (enjoy the game as a fun and entertaining experience).
The results grouped by courses (group of "Computer Tools 2" of Architecture degree La Salle, and group of "Multimedia" of degree Architecture UPC) we can observe them in the following Fig.5.

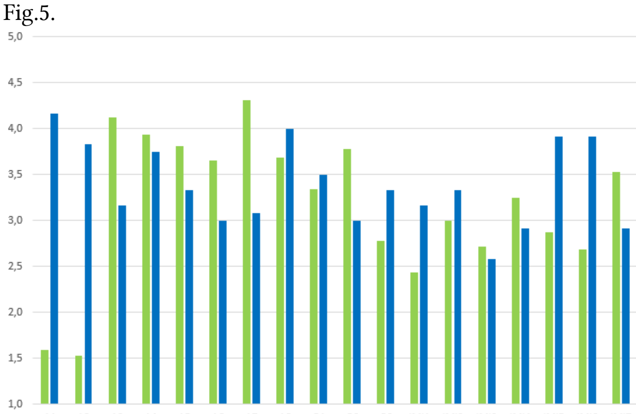

Figure 5: Pre-Test (Salle vs. UPC)

Although there are variables where there is a clear difference between the perceptions of the two groups (e.g. A1, A2, A7, IM5 or IM6), the average of all variables is similar (3.2 vs. 3.4), and the same happens if we grouped by global variables (A: 3.3 vs. 3.1, G: 3.3 vs. 3.3 and IMI: 2.9 vs. 3.3).

Once the course has been completed, the students have had to make the urban proposals for the “pedestrianization” of specific streets in Barcelona (see Fig. 6). Finally, they had to integrate their proposals into the interactive system for visualization (Fig. 7). After that, a Post-Test was performed in which, in addition to repeating the initial variables, they were asked about certain aspects related to usability and satisfaction with the proposed method.

Figure 6: Mobile Roof Proposal

Figure 7: Example of student navigation/interaction

Fig. 8 shows the results obtained from the Post-Test, differentiated by groups. Globally, the indices have increased in value from an overall average of 3.30 to an average of 3.75.

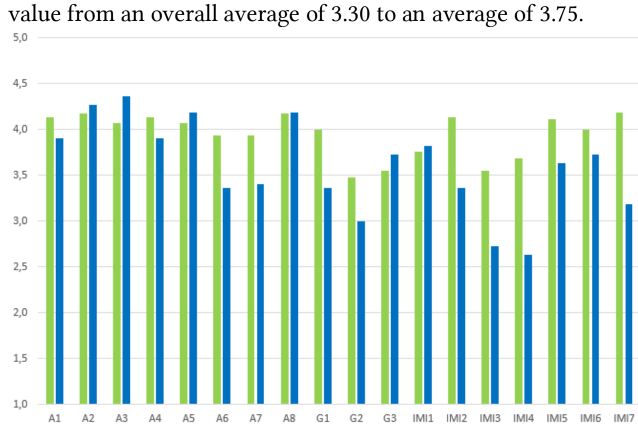

Figure 8: Post-Test (Salle vs. UPC)

The largest increase has been achieved in the student group of La Salle, who have gone from an overall average of 3.2 to 3.9 (see Fig.9)

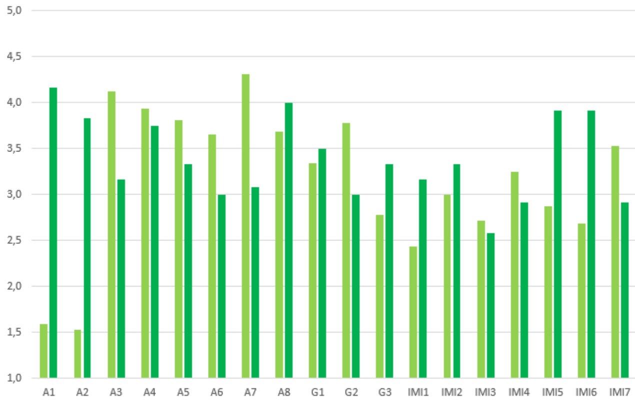

Figure 9: Comparative Pre. Vs. Post (Salle)

The group of the Multimedia subject of the UPC also has increased in average the perception of the variables, going from 3.4 to 3.6 (see Fig. 10).

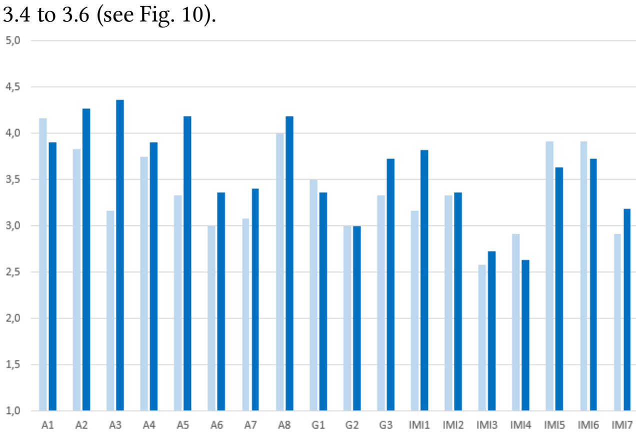

Figure 10: Comparative Pre. Vs. Post (UPC)

Studying the changes obtained by the variables, we highlight the increase of 1 point (from 2.9 to 3.9) of the IMI average of the group La Salle, students with a lower initial knowledge of the techniques and technologies used in the UPC group. In the case of these latter students, the largest increase is obtained in-group A (from 3.5 to 3.9), in line with the response of La Salle students (also with a significant increase of 3.3 to 4.1).

5 CONCLUSIONS

The present work analyzes the impact of including new interactive and gamified visualization systems in the development of the urban project as an educational tool of the degree in architecture. Although the funded project in which the work is framed is in the development of the first cases of pilot study, it is clear that initially the students are not especially motivated by the use of digital systems that are far from the needs demanded by the most projective subjects. It is easy to determine that students consider the technology necessary as much as in the main subjects this is necessary to develop their work.

However, the continuous advancement of ICTs and teaching approaches may allow systems such as games, interaction or real-time rendering to be used in areas such as urban design or project design. The initial reluctance logic is overcome when the results can be seen.

The article confirms this evolution of the student, especially in terms of motivation and the perception that the systems used can have in the representation of both architectural and urban projects. While initially the motivation could be considered medium / low, after the completion of the case study, it has increased significantly, an aspect that not only reflects the usefulness of the method, but also the potential in the academic and competence improvement of the student, which previously had already been referenced is linked to the student's motivation.

The project in sub-following phases will improve the navigation and interaction of the system to adapt it to the needs of each urban zone, all of which will be introduced cyclically in the contents of the subjects to involve the student in real projects.

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