Interactive virtual method applied in urban design education. Mixed Approach

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DOCTORAL THESIS

Title	Interactive virtual method applied to urban design education. Mixed Approach.
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Abstract

The memory of this thesis deals with the use of digital transformation in the teaching and processes of urban design, through innovative concepts and practical methodologies. The objective is to promote the use of digital technologies, in particular, to evaluate the inclusion of virtual reality in various formal and informal teaching environments of collaborative urban design, in order to improve it, speed up, and increase its positive social impact and improve university teaching by helping students consolidate their skills more effectively.

With the characteristics of the VR system, we can test our hypothesis based on demonstrating: (1) The use of virtual-interactive systems for the understanding of three-dimensional space improve in students and professionals the perception of the comprehension of the space, generating a greater understanding of the location conditions, dimensions and relationships of urban spaces, and defend the arguments of urban projects and interactively defined urban proposals rehearsing various strategies of action. (2) The implementation of virtual gamified strategies in the field of urban design will generate improvement and motivation in citizen participation and students as it is a more dynamic, real and agile collaborative environment thanks to the immersive visual technologies as they critically evaluate the result of the urban design and make decisions.

To validate our hypothesis, we use a quantitative and qualitative method applied in different scenarios and to a different profile of users, students, professionals and end users. The results will show that it is possible to empower digital transformation, to improve public motivation, implication, and satisfaction in urban decision-making processes as well as complementing the improvement of the perception of the comprehension of the space needed for the profession in Architecture students.

Resumen

La memoria de esta tesis trata sobre el uso de la transformación digital en la enseñanza y los procesos de diseño urbano, a través de conceptos innovadores y metodologías prácticas. El objetivo es promover el uso de tecnologías digitales, en particular para evaluar la inclusión de la realidad virtual en diversos entornos de enseñanza formales e informales del diseño urbano colaborativo, con el fin de mejorarlo, acelerar y aumentar su impacto social positivo y mejorar la enseñanza universitaria ayudando a que los estudiantes consoliden con mayor efectividad sus habilidades.

Con las características de un sistema de realidad virtual, podemos probar nuestra hipótesis en función de demostrar: (1) El uso de sistemas virtuales interactivos para la comprensión del espacio tridimensional mejora en los estudiantes y profesionales la percepción de la comprensión del espacio, generando mayor entendimiento de las condiciones de ubicación, dimensiones y relaciones de los espacios urbanos, y defender los argumentos de proyectos urbanos y propuestas urbanas definidas interactivamente que ensayan diversas estrategias de acción. (2) La implementación de estrategias virtuales gamificadas en el campo del diseño urbano generará una mejora y motivación en la participación ciudadana y en los estudiantes, ya que es un entorno de colaboración más dinámico, real y ágil gracias a las tecnologías visuales inmersivas, mientras evalúan críticamente el resultado de un diseño urbano y toman decisiones.

Para probar nuestras hipótesis, utilizamos un método cuantitativo y cualitativo aplicado en diferentes escenarios y a diferentes perfiles de usuarios, estudiantes, profesionales y usuarios finales. Los resultados mostrarán que es posible potenciar la transformación digital, mejorar la motivación pública, la implicación y la satisfacción en los procesos de toma de decisiones urbanas, así como complementar la adquisición de competencias urbanas específicas necesarias para la profesión en estudiantes de Arquitectura.

Resum

La memòria d'aquesta tesi tracta sobre l'ús de la transformació digital en l'ensenyament i els processos de disseny urbà, a través de conceptes innovadors i metodologies pràctiques. L'objectiu és promoure l'ús de tecnologies digitals, en particular per avaluar la inclusió de la realitat virtual en diversos entorns d'ensenyament formals i informals del disseny urbà col·laboratiu, per tal de millorar, accelerar i augmentar el seu impacte social de forma positiva i millorar l'ensenyament universitària ajudant al fet que els estudiants consolidin amb major efectivitat les seves habilitats.

Amb les característiques d'un sistema de realitat virtual, podem provar la nostra hipòtesi en funció de demostrar: (1) La implementació d'estratègies virtuals gamificades en el camp del disseny urbà generarà una millora i motivació en la participació ciutadana i dels estudiants, ja que l'entorn és més dinàmic, real i permet un disseny col·laboratiu àgil gràcies a les tecnologies visuals immersives, mentre avaluen críticament el resultat d'un disseny urbà i prenen decisions. (2) L'ús de sistemes virtuals interactius per a la comprensió de l'espai tridimensional millora en els estudiants i professionals la percepció de la comprensió de l'espai, generant major enteniment de les condicions d'ubicació, dimensions i relacions dels espais urbans, i defensar els arguments de projectes urbans i propostes urbanes definides interactivament que proven diverses estratègies d'acció.

Per provar les nostres hipòtesis, fem servir un mètode quantitatiu i qualitatiu aplicat en diferents escenaris i als diferents perfils d'usuaris, estudiants, professionals i usuaris finals. Els resultats mostraran que és possible potenciar la transformació digital, millorar la motivació pública, la implicació i la satisfacció en els processos de presa de decisions urbanes, així com complementar l'adquisició de competències urbanes específiques necessàries per a la professió en estudiants d'Arquitectura.

Regulations for Doctoral Theses by Compendium of Publications

One of the expected impacts of this thesis is linked to the dissemination in international congresses and scientific journals of impact. This doctoral thesis is based on the *Regulations for the Preparation of Doctoral Theses by Compendium of Publications of the Ramon Llull University*. The regulations consist of the following points:

1. *A doctoral thesis by compendium of publications will consist of a minimum of three articles on the same line of research.*
2. *Only articles from publications that have a peer-review evaluation system and/or that are preferably indexed in international scientific databases will be accepted.*
3. *Only articles published or accepted for publication, made after the first enrollment of the doctoral student to doctoral studies or master's degree will be accepted.*
4. *The co-authors of the articles will give their written consent to the use of the article as part of the doctoral thesis.*
5. *Co-authors of the published articles will not be part of the thesis tribunal.*
6. *Co-authors of the articles published and used in a thesis that does not have the degree of doctor will resign in writing to use the article in another thesis. The Academic Committee of the Doctoral Program may consider justified exceptions in the application of this standard, with the approval of the Doctoral Commission of the URL*
7. *The thesis will have, at least, a general introduction that presents the published works and the specific contribution of the doctoral student, a justification of the thematic unit, a copy of each published work, a global summary of the results, its discussion and the final conclusions.*
8. *For all the above, there will always be, before the thesis is deposited, a formal application presentation to the Academic Committee of the Doctoral Program and its favorable acceptance, which will ensure the quality of the publications that are to be*

submitted for the thesis. To this request will also be added a report from the thesis director indicating the specific contribution of the doctoral candidate to the work presented and that of the other authors, if relevant.

It will be necessary to present the certificate of approval of the Academic Commission of the Doctoral Program in the Doctoral Commission of the URL at the time of the ordinary processing of the Thesis.[1]

This thesis complies with all the previously mentioned points. The articles presented in the compendium are the following:

a. **Evaluation of interactive educational system in urban knowledge acquisition and representation based on the students' profile.** Monica Sanchez-Sepulveda, David Fonseca, Alicia Garcia-Holgado, Francisco Jose Garcia-Peñalvo, Jordi Franquesa, Ernesto Redondo, Fernando Moreira. Expert Systems May 2, 2020. Ed. Jon G. Hall. ISSN: 0266-4720. WILEY NU, ENGLAND. JCR: Q2 (IF: 1.505)
b. **Methodologies of Learning Served by Virtual Reality: Case Study in Urban Interventions.** Mónica Vanesa Sánchez-Sepulveda, Ricardo Torres Kompen, David Fonseca Escudero, Jordi Franquesa-Sánchez. Applied Sciences-Basel (CODEN: ASPCC7) ISSN: 2076-3417 MDPI, BASEL, SWITZERLAND. November 28, 2019. Vol. 9 (23), 5161DOI:10.3390/app9235161. JCR Q2 (IF: 2.217)
c. **Virtual interactive innovations applied for digital urban transformations. Mixed approach.** Mónica Sanchez-Sepulveda, David Fonseca, Jordi Franquesa, Ernesto Redondo. Future Generation Computer Systems. ISSN: 0167-739X. ELSEVIER SCIENCE BV, AMSTERDAM, NETHERLANDS. September 9, 2018. Vol. 91 - February 2019, pp. 371-381. DOI: 10.1016/j.future.2018.08.016. JCR: Q1 (IF: 5.768)

[1] Update approved by the Doctoral Commission of the URL of 07/13/2016

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Acronyms

CRUE	Conference of Rectors of Spanish Universities
CADEP	Environmental Quality, Sustainable Development and Risk Prevention in Universities
CSCS	Crue-Sustainability Sector Commission
ETSAB	Higher Technical School of Architecture of Barcelona
ETSALS	Higher Technical School of Architecture La Salle
GRETEL	Technology Research Group for Enhanced Learning Research
GTSC	Curriculum Sustainability Working Group
ICT	Information and Communication Technologies
SUE	Spanish University System
UPC	Polytechnic University of Catalonia
URL	Ramon Llull University

1 Introduction

1.1 Motivation

The moment I decided to come to Barcelona in 2015 I was working in Puerto Rico as Urban Design Manager, while engaged at the University as a researcher and professor in Urbanism. I came to Barcelona to dive in the doctorate's journey in Urbanism at the Polytechnic University of Catalonia. Back then, my main concern was about the relationship of the Urbanist related to environmental demands. While working on the thesis of the master's Degree in Advanced Studies in Architecture my concern got even broader; it was now about the relevance of what urbanists are putting their efforts on, mostly how is taught at the University. How are approaches and tools changing to deal with critical urban challenges? How well do Urbanism concepts travel, are communicated and taught, and to what extent are they culturally-bound?

Although learning is a puzzling act, the learning of a discipline like Urbanism is a particular one because of the interdisciplinarity that this field requires in actual society. In many Schools of Architecture, where this discipline is taught, we can find the nostalgia of the urbanist locked in a knowledge and skills that hardly seems to be practical versus the panorama of uncertainties and new possibilities in which we live. Overcoming the resistance to superficiality, looking at a world that cannot be renounced and with a renewed dose of responsibility, is the education in Urbanism responding well to the constant changes and equipping urbanists to lead the resolution of the challenges of our society?

As a professor, student and professional in the field of Urbanism I believe that in the modern changing world, each project emerges out of a careful analysis of contemporary life, enhanced with new technologies, and therefore I wish to combine the applicative theory and reflective practice to implement methods that provide examples of good practices. This motivates me to research the education of Urbanism, and to leave a record of practices that work to keep

improving in the field. It motivates me to study one step forward of how the urbanist of this era is, how he learns and how are we teaching them to look at the world's challenges.

Studying the current educational processes involves the theoretical contextualization of the educational act, the educational discourses and the historical revision of the evolution of its structure. This research deals with the competences that affect education in the Schools of Architecture, the practical functions used in the professional field, and the perspective of the end-user or client.

Furthermore, to complement this study, which generally covers Urbanism courses, it is relevant to analyze the small particles of one specific case, with full access, in order to evaluate and validate the application of innovative methods, processes and its results. A local project is chosen and tested in Barcelona, with students, neighbors and professionals in the field of Architecture and Urbanism. The aim is not to generate an accurate portrayal of the Architecture Schools but to use examples to present arguments that constitute the theoretical contextualization of the pedagogical act in Urbanism courses.

1.2 Hypothesis and Objectives

The main objective lies in promoting the use of digital technologies in a collaborative way in order to pro-actively improve professional proposals in the architecture and urban planning sector. Current urban design projects are incorporating participatory processes, but these are often not sufficiently interactive or agile apart from not abounding in the formal education of future architects. In this regard, it seeks to demonstrate:

- Traditional methodologies for training in urban projects, ETSAB-UPC (Barcelona School of Architecture, Polytechnic University of Catalonia) and ETSALS-URL (La Salle School of Architecture, Ramon Llull University) can be improved by incorporating PBL (Project-Based Learning), collaborative and informal data methodologies.

- The new ICTs (Information and Communication Technology) and the VR (Virtual Reality) with glasses, as well as the gamification of urban scenarios, provide new perspectives that facilitate a more effective design as well as a more motivating teaching, being necessary for the formation of the future architect.
- The generation of serious games dedicated to the project-user interaction as a method of citizen participation and/or as an informal educational method of the urban project by other students, will substantially improve the understanding of the problem and the possibilities of solving it successfully by all the groups involved.

The principal hypotheses of this research are:

- **H1.** The use of virtual-interactive systems for the understanding of three-dimensional space improve in **students and professionals** the perception of the comprehension of the space, generating a greater understanding of the location conditions, dimensions and relationships of urban spaces, and defend the arguments of urban projects and interactively defined urban proposals rehearsing various strategies of action.
- **H2.** The implementation of virtual gamified strategies in the field of urban design will generate an improvement and motivation in **citizen participation and students** as it is a more dynamic, real and agile collaborative environment thanks to the immersive visual technologies as they critically evaluate the result of the urban design and make decisions.

To venture into the work hypotheses, three lines of research are valued. These lines will be the conductive objectives that allows structuring the research.

- **L1.** Analyze the concept of Urbanism as a discipline from the training to the practice and examine the use of ICTs in the training of courses related to urban design. Prepare surveys to study the profile of the students (technological and social aspects), as well as the degree of motivation in the use of technologies and their future applications. (H1 and H2)

- **L2.** Test the usefulness of digital tools in the management of urban projects related to the urban designer required competences. Evaluate the relationship of methodologies such as ICTs and gamification to the general and specific phases of the urban design, through professionals and students in the Architecture field. Determine the correlation between motivation, satisfaction and experience of use, and the improvement of space. (H1)
- **L3.** Evaluate the usability, motivation and satisfaction of the serious games applied to the field of teaching of the urban project, citizen participation and involvement in the simulation of processes for decision-making and design. The profile of the end-users and students will be evaluated, their motivation in the use of ICTs and finally their degree of satisfaction with the gamified systems used. (H2).

All collected data will be studied and analyzed quantitatively and qualitatively, that is, using a mixed approach.

1.3 Innovation and Context

This work is carried out within the Doctoral Program that is entitled *Information Technologies and its Application in Management, Architecture and Geophysics*, enclosed to La Salle, Ramon Llull University. The Royal Decree 99/2011, of January 28, regulates this program.

This research arises from the support of the Research Group in Technology Enhanced Learning (GRETEL) recognized from La Salle, Ramon Llull University, and supported by the National Program of Research, Development and Innovation aimed to the Society Challenges with the references BIA2016-77464-C2-1-R & BIA2016-77464-C2-2-R, both of the National Plan for Scientific Research, Development and Technological Innovation 2013-2016, Government of Spain, titled “Gamificación para la enseñanza del diseño urbano y la integración en ella de la participación ciudadana (ArchGAME4CITY)”, & “Diseño Gamificado de visualización 3D con sistemas de realidad virtual para el estudio de la mejora de competencias motivacionales, sociales y espaciales del usuario (EduGAME4CITY)” (AEI/FEDER, UE).

There is a need to research in two themes:

1. Design and evaluation of gamification in the formal and informal education of the urban project and the integration of citizen participation in it.
2. Gamified 3D visualization design with virtual reality systems for the study of the improvement of motivational, social and spatial skills of the user.

The two themes start from a common point: the concern for improvement in architectural teaching through the implementation of the new visual systems. One of the benefits of the proposal lies in the combination of a public entity (UPC), and a private one (URL). This generates a multidisciplinary approach capable of reaching different agents of our society effectively: at an educational level (schools, institutes and universities especially thanks to the La Salle network), as public institutions, professional offices and other organizations (usual scope of work of the UPC network and La Salle).

One of the most innovative aspects of the project is the inclusion of game strategies in the urban collaborative environment to improve its initial proposal. This approach becomes part of the project, used by the professionals in charge of the design and execution of the project, the students who are being trained for these future tasks, as well as the end-users (citizens), who can provide points of view not contemplated and very useful for the project.

From the point of view of the urban project, the drastic processes of urban concentration and transformation at a global level have continued to accelerate vertiginously in recent years to the point of reaching a dynamism difficult to represent, formalize and manage. Therefore, it is needed to offer this type of knowledge to a more global audience, to the future architect, the current designer of public spaces and to the end-users.

The use and mastery of ICT (Information and Communication Technologies), is a challenge of today's society, at the training level, at the professional level and finally in any layer of society. This challenge is complicated to achieve in itself due to various factors such as: the high speed

in the appearance, improvement, and even disappearance of all kinds of technologies, the high costs of some of them, the difficulty of use that they entail, or simply the lack of opportunities for certain ICTs to adapt widely to all levels of society, due to costs or simply support for use.

However, and as has been studied and demonstrated in many recent research (references on Chapter 2), the use of mobile devices, technologies such as virtual reality (VR), augmented reality (AR), collaborative work, and gamified strategies (also known as Serious Games), are penetrating our society thanks to their ease of use and efficiency, in formative stages, and later in professional and social fields. With "wearables" technologies such as AR or VR Head Mounted Display, Smartphones, Tablets, Smartwatches, etc., we can work with the defined urban proposals in order to test various action strategies interactively, collaboratively evaluating public spaces thanks to the collaboration of all the agents described previously. In this way, two vital agents are incorporated into the project: the end user/citizens, thanks to their participation as an active element of the project; and to the student, who will have the ability to learn in real environments and projects (what is known as Project-Based Learning). Even acting with a specific role that allows them to obtain and improve his spatial and social skills in a much more optimal way, formally and informally.

Starting from a critical approach, the first question that may arise is: What do serious games contribute to these processes? The answers are multiple. First, game strategies have been demonstrated as an element of learning or decision-making very interesting, useful and applicable in various areas of knowledge (marketing, business, formal education, non-formal education, etc.). On the other hand, other answers about the usefulness of serious games can be obtained in the current demonstrations about the contribution of a higher degree of motivation in the follow-up of the gamified contents, the increase of the participation they suppose, and of course in the inherent dynamism that they contribute to these contents. These answers are nothing more than conclusions from many previous works in all types of professional fields (more information and references in Chapter 2).

The main contribution of this thesis lies in the proposal of teaching methodologies for the improvement of the perception of the comprehension of the space of students incorporating new technologies in the representation of urban projects. Undoubtedly, a fundamental and differentiating aspect of this thesis is the fact that it is usually not easy to find studies in the branch of Urbanism that assess the degree of motivation or adaptation of the student to pedagogical innovations and less when they incorporate technology. The social/pedagogical approach, together with obtaining the feedback of the end user, are aspects that improve the student's training in architecture for their future projects and enable it to successfully pursue their professional career.

Scientific-technical impact

Logically, we can highlight other aspects that are much more imminent and closer to the teaching field. For instance: thanks to the VR applications that we propose to incorporate in the teaching flow and that are references in the current generational change, improve the teaching of the Architecture degrees, with an adaptation of the technical means to the future needs of their professions. These educational improvements allow the creation of scientific-technical knowledge to the research groups and Universities involved, reverting to the teaching and professional improvement of the sector.

The educational/professional network of the UPC, as well as the educational/professional network of La Salle, with thousands of schools throughout the world usually connected in the process of sharing technical/scientific information, support a high project impact, with multiple possibilities for future extension and replication, which in turn impact on the social and economic aspects of it.

Social and/or economic impact

The possibility of having the opinion of future users about urban proposals quickly, thanks to the gamified systems, is an aspect of high social impact (due to the universalization of access to information and participation). This aspect not only has a social impact, but directly in the

economic field of administrations and professionals in the sector, having the opportunity to modify the proposals of the designs in early phases and in a cyclical way. The project generates new diagnostic flows of social and educational needs, improving the spatial competences of any user who uses the gamified proposals. This proposal currently has an adequate base of expansion, thanks to the popularization of Smartphones and tablets, and devices that allow a great immersion of the user for VR at a low cost.

Secondly, the usability and motivation generated by these serious gaming platforms will allow new users, new opinions and new ways of acting in the process of discussing the urban project to be effectively incorporated into the process, as long as the rules of the game are logical and adapted to the needs of the acting environments. The possibility of emulating virtually routes or itineraries within the virtual scenarios will allow detecting architectural barriers, studying evacuation routes, and areas where to install certain technical elements. In summary, is expected a clear impact on the improvement of the usability and universal accessibility of urban environments through our gamified systems.

Regarding the economic impact, our proposal aims to generate games applied to the field of teaching urban design and citizen participation with immersive visualization tools and realistic virtual scenarios that incorporate the landscape and the pre-existing environment. Based on rigorous proposals of urban design and with quality of final visualization professional type, a niche of the market that need to be explored.

1.4 Methodology

To assess the best way to deal and define more precisely the empirical approach from which the research is based, and what processes are going to be carried out to obtain, measure, analyze and discuss the data, a brief description of each approach is studied. When defining the methodology of this research, it is important to note that the work will be divided into two stages: the first part will be the theoretical framework and the second the empirical work.

When talking about methodology, in the case of research, has to do with the resolution of previously asked questions and the acquisition of new knowledge as a result of research, a knowledge that comes derived from the systematic and objective analysis of the object of study proposed. In this case, the research field is interdisciplinary, since it covers issues related to education, urbanism and technologies.

The integration of digital transformation in Urbanism consists of balancing the creative act required to generate receptive environments and the social and environmental responsibilities that should be integrated into this act. It is about understanding how knowledge is produced, what are components of that knowledge and which are the learning processes and social practices that can be used to transmit it. This, with the goal to present the use of Virtual and Interactive Transformations in the teaching and processes of urban design, practical methodologies. Understanding that, if something exists, it exists in a certain amount and, therefore it can be measured. This is a postulate that appears in positivist theory (García-Sánchez, 2019) from the quantitative approach.

The quantitative research focuses on analyzing the degree of association between quantified variables, as promulgated by logical positivism; therefore, this method requires induction to understand the results of the investigation. Because this paradigm considers that phenomena can be reduced to empirical indicators that represent reality, quantitative methods are considered objective (Sale et al., 2002; Vigo et al., 2011).

From this approach, the researcher distinguishes an independent and complex reality and it is positioned in an objectively way, using deductive reasoning (Briz Ponce, 2016; García-Sánchez, 2019). Do not interacts with what is observed, but states questions and hypotheses from the beginning and, with the answers obtained, inductively seeks a relationship that proves the stated in these hypotheses. This work is going to be carried out by various questionnaires administered, which will generate results that will be translated into numerical values to represent a general sample of the results.

In addition, what exists in reality exists thanks to a kind of qualities that can be observed and categorized to propose a solution from their understanding. The qualitative approach appears from the phenomenological theory or constructivist, where the researcher observes a subjective and concrete reality, both the researched and the researcher himself, merge to obtain a holistic view of the problem addressed (Hernández et al., 2014). The qualitative method allows observing through deductive reasoning and from a field job. Unlike quantitative methods, qualitative methods require deduction to interpret results. The qualitative approach is subjective, as it is assumed that reality is multifaceted and not reducible to a universal indicator (Pfeil & Zaphiris, 2010).

Quantitative and qualitative approaches have historically been the main methods of scientific research. In each of these two approaches, you can find the quantities and qualities that are being sought. From post-positivist theory, which seeks knowledge in general to get to the particular, appears the combination of various methods for data collection, and thus the mixed approach arises (Hernández et al., 2014; Popper, 1980). A hybrid approach to an experimental methodology that takes a more holistic view of methodological problems. This model is based on a pragmatic paradigm that contemplates the possibility of combining quantitative and qualitative methods to achieve complementary results. The value of research lay not so much in the epistemology of the method but its effectiveness (Teddlie & Tashakkori, 2004).

This mixed approach analyzes and collects evidence that allows the interpretation and observation of the data obtained. Therefore, the mixed approach methodology will be essential in this research, as a means of organization to address the entire process, to observe, present, collect and analyze the data. The mixed approach proposes the integration of quantitative and qualitative approaches to facilitate the interpretation of experimental results. This combination of quantitative and qualitative experimental designs leads to a wider variety of results when dealing with human factors that include both numerical results and the basis for these results. The possibility to work with both types of information simultaneously in a single study is a great

advantage to a research team: multidimensional outcomes make it much easier to propose solutions and further research steps in a given field of study (David Fonseca et al., 2015).

We use for this thesis the mixed approach, combining predesigned surveys that give us quantitative information, and through personal interviews, the qualitative information that complements and justifies many of the variables worked quantitatively. For this second system, we will use the BLA (Bipolar Laddering Assessment), a technique used in usability studies and that has demonstrated its validity and adaptation to mixed studies such as the one we propose.

Quantitatively we will make an approach to the profile of students and users through a Pre-Test where we will capture information on: Age, sex, origin, type of studies, ICTs commonly used, usual ICT uses, previous experiences with ICTs, etc. With a Post-Test, we will analyze the degree of satisfaction with the teaching experience (in the case of students), and with the gamified experience (in the case of citizens).

Method (case study phases defined sequentially)

In the first phase, the AMB will select areas of action in which to address a new public space project, either completely new or renovate an existing one (described on Chapter 3). For the educational process, the professors will guide the students in the definition of various alternatives after a detailed “traditional” analysis of the information provided by the AMB, the site visit and the study and preparation of all the available documentation of the area to work. In this phase the design premises from the point of view of the needs of future users are provided by the AMB or the experience of urban planning professors and the usual graphic representation techniques will be used.

In a second phase, these preliminary projects will be addressed by the UPC Architectural Representation students for the generation of virtual models and scenarios that collect all the elements of the urban composition described above, completing them with the appearance of materials, textures, sunning, topography, woodland, incorporation of sculptural elements, etc.

Up to this point, the current representation techniques common to the field of architecture would be worked on. This phase is important since we are not simply talking about modeling and representation, but about the decision of the structural work of the project.

In parallel to this phase carried, and pending the definition of a case to gamify, La Salle-URL will define the variables and indicators to evaluate the formal educational process, as well as the informal system and the citizen approach. In this regard, a series of Pre-Test will be designed adapted to the study of the demographic, technological, motivational and spatial competences profile of the user. After, we will work with a Post-Test that allows to evaluate the degree of usability, based on effectiveness, efficiency and user satisfaction with the proposed methods.

Once the phases 1 and 2 are finished, and jointly with UPC, first immersive visualization proposals of the scenarios generated using VR Head Mounted Display, or the adaptation of mobile devices will be developed. The first proposal of gamification made on the Unreal Engine platform will address small games that seek to emulate the behavior of certain users and the recognition of key environmental conditions. UPC will define the areas and routes to be modeled, while La Salle will define the qualities and characteristics necessary for effective gamification both in VR and in mobile platforms.

Within the degree of Multimedia Engineering of La Salle students collaboratively, will make the multiplatform gamification proposal that adapts to mobile devices and VR based on the work areas described and provided by the UPC. This will be evaluated based on a PBL-based system adapted to the real needs of our society, which entails a significant change concerning the current work system based on non-real mini-projects to gamify. In this phase, designed questionnaires will be introduced from early stages, in terms of usability and educational research in the field of architecture to obtain profile data. The test will evaluate the usability and satisfaction once they have applied these ICTs to a teaching experience. Likewise, the emotional variables in the use of the proposed systems are controlled: educational gamification for decision making and use of AR/VR.

Sequentially, the first games to be evaluated by students from UPC and La Salle will be generated, preferably by those that are taking the subject of Urban Design in a traditional way, that are in the initial phase of their training and that have not participated in the design of the selected public spaces. In this phase the citizen behavior is simulated, although considering the error of bias that can produce a profile related to the developed work. From this interaction, we will get the first answer about:

- Usability of the gamified system.
- Need for changes in the gamified platform and in the modeling system to obtain the definitive system with which citizens will work.
- First informal data to consider in Architecture to modify the methods of modeling the site.
- The emotional component of the student of an educational system based on PBL, and the use of Gamification and visual ICTs (motivation and satisfaction).

Based on these results, students and professors involved in the design, representation, and programming phase must rework the scenarios, virtual models, game dynamics and new interactive elements in order to generate the final version of the games, while learning how to generate them based on the dynamics of formal education. The final version of the games will be developed on a single model that will incorporate the most outstanding options provided by previous users and the different levels of interaction of non-expert users and teaching content that are considered accurate, design criteria, restrictions, etc.

Through the mixed method used and validated in our previous work, we will be able to obtain a detailed response of the experience, proceeding to generate documentation and dissemination of results. (Figure 1)

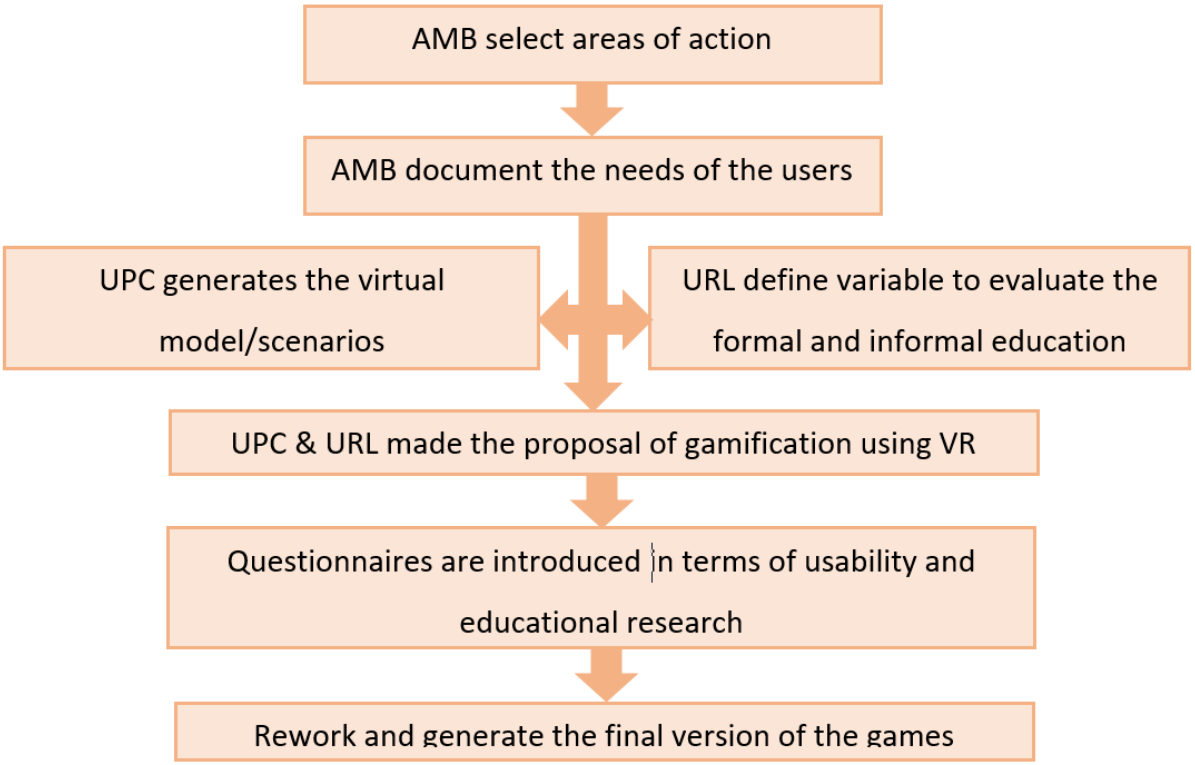

Figure 1: Scheme summarized of the Method.

1.5 Research Structure

The document is organized around seven chapters, reflecting on the development of the research work. The research started the last month of 2016 at the Polytechnic University of Catalonia. During the first year at the UPC the Introduction and big part of the Theoretical Framework were made. Then transfer to La Salle, Ramon Llull University to continue with the Empirical Work and finish the investigation.

The introduction shows a preamble to the Thesis. It is composed of five parts, that present the objectives and hypotheses of the investigation, the phases, and the methodology by which the investigation is carried out. The next two chapters consist of the theoretical and empirical work of research.

It studies several terms related to the work and evaluates the relationships that arise between them, along with a reflection and approach to the state of the matter. These two chapter shows the tools with which it has been investigated and the experimentation that is carried out. Chapter four presents the chronology of the compendium to demonstrate the main lines of this research, and a copy of the three published articles with the results of this investigation. The fifth chapter focus on a global summary of the results, its discussion and the final conclusions.

This generates a discussion about the future lines of research and additional results for the continuation of this research. The sixth and seventh chapter serves as a compilation of the references used throughout the research and the articles that are part of the investigation and are included here for your inquiry.

During the initiation phase was developed the problem statement and literature study, followed by an exploratory phase where the case study was studied and tested, then the descriptive phase began understanding and analyzing the results, to finish with a conclusive phase where the interpretation and final conclusions were made.

During this period, eleven articles were written regarding the project of this thesis, and three of them are used for the main content of it. (Figure 2)

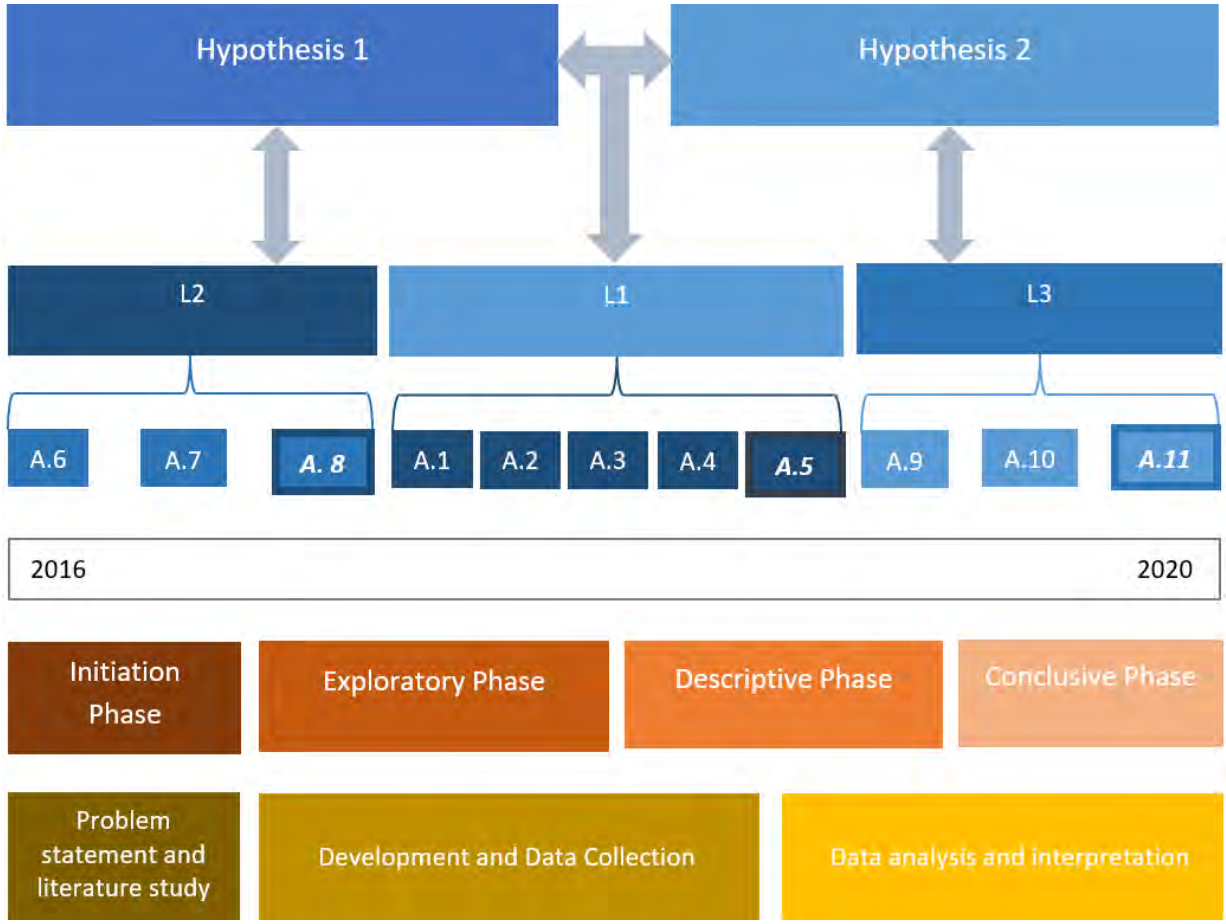

Figure 2: Scheme of the Phases, Tasks, Years, Lines of Objectives and Articles developed during the thesis. L is for the Lines described in the 1.2 Hypothesis and Objectives and A is for the articles mentioned under. A.5, A.8 and A.11 are the selected articles for

List of Journal Papers and Conference Articles related to the research:

1) **Teaching and learning urbanism in architectural schools**

   Mónica V. Sánchez-Sepúlveda, Jordi Franquesa, David Fonseca, The IAFOR International Conference on the City. July 13-15, 2018 Barcelona, Spain. pp. 23-27, ISSN: 2432-4264, Official conference proceedings FEARFUL FUTURES. Cities in the twenty-first century. ***IAFOR Scholarship Award***

2) **Introducing a new ICT tool in an active learning environment course: performance consequences depending on the introduction design**

   José Antonio Ferrándiz, Fernando del Ama Gonzalo, Mónica Sánchez-Sepúlveda, David Fonseca, International Journal of Engineering Education. ISSN: 0949-149X. Accepted date: October 17, 2018, published 2019, Vol. 35, No.1B, pp.360-371. JCR Q4, SJR Q1.

3) **Programming virtual interactions for gamified educational proposes of urban spaces**

Xavier Calvo, David Fonseca, Mónica Sánchez-Sepúlveda, Daniel Amo, Josep Llorca, Ernest Redondo, HCI-International 2018 - Zaphiris P., Ioannou A. (eds) Learning and Collaboration Technologies. Learning and Teaching. LCT 2018. Lecture Notes in Computer Science, vol 10925. Springer, Cham. July 15-20, 2018 Las Vegas, Nevada, USA, pp.128-140, Print-ISBN: 978-3-319-91151-9, DOI: 10.1007/978-3-319-91152-6_10

4) **Qualitative assessment of urban virtual interactive environments for educational proposals**

Xavier Calvo, Mónica Sánchez-Sepúlveda, David Fonseca, Nick Van der Graaf, Miquel Sans, Marc Gené, Isidro Navarro, Sergi Villagrasa, Ernesto Redondo, TEEM2018 - 6th Technological Ecosystems for Enhancing Multiculturality. Ed. Francisco José García-Peñalvo, University of Salamanca. October 24-26, 2018 Salamanca, Spain, pp.716-722, ISBN: 978-1-4503-6518-5. DOI: 10.1145/3284179.3284295

5) **Evaluation of interactive educational system in urban knowledge acquisition and representation based on the students' profile**

Monica Sanchez-Sepulveda, David Fonseca, Alicia Garcia-Holgado, Francisco Jose Garcia-Peñalvo, Jordi Franquesa, Ernesto Redondo, Fernando Moreira. Expert Systems 2020. Ed. Jon G. Hall. ISSN: 1468-0394. Accepted date: April 6, 2020, Published: May 2. DOI: 10.1111/exsy.12570. JCR Q2, SJR Q2.

6) **Innovation in Urban Design Education**

Monica Sanchez-Sepulveda, David Fonseca, Xavier Calvo, Isidro Navarro, Jordi Franquesa, Ernesto Redondo, Marc Gené, TEEM2018 - 6th Technological Ecosystems for Enhancing Multiculturality. Ed. Francisco José García-Peñalvo, University of Salamanca. October 24-26, 2018 Salamanca, Spain. pp.729-736, ISBN: 978-1-4503-6518-5, DOI: 10.1145/3284179.3286731.

7) **Collaborative Design of Urban Spaces Uses: From the Citizen Idea to the Educational Virtual Development**

Monica V. Sanchez-Sepulveda; David Fonseca; Jordi Franquesa; Ernesto Redondo; Fernando Moreira; Sergi Villagrasa; Enric Peña; Nuria Martí; Xavier Canaleta; José Antonio

Montero, Masaaki Kurosu (eds) Human-Computer Interaction. Design Practice in Contemporary Societies - Thematic Area. Held as Part of the 21st HCI International Conference, HCII 2019. Proceedings, Part III. Lecture Notes in Computer Science 11568, Springer 2019, ISBN 978-3-030-22635-0 Online ISBN: 978-3-030-22636-7, pp. 253-269, June 27, 2019 Orlando, FL, USA.

8) **Virtual interactive innovations applied for digital urban transformations. Mixed approach**

Mónica Sanchez-Sepulveda, David Fonseca, Jordi Franquesa, Ernesto Redondo

Future Generation Computer Systems. ISSN: 0167-739X, Accepted date: August 7, 2018, On-line: September 9, 2018. Vol. 91 - February 2019, pp. 371-381, DOI: 10.1016/j.future.2018.08.016, JCR Q1, SJR: Q1.

9) **Visual Technologies for Urban Design Competences in Architecture Education**

Mónica V. Sánchez-Sepúlveda; Nuria Marti-Audi; David Fonseca, In Proceedings of TEEM 2019. TEEM'19 - Technological Ecosystems for Enhancing Multiculturality, October 16-18, 2019, León, Spain, pp. 726-731, ISBN: 978-1-4503-7191-9/19/10

DOI: 10.1145/3362789.3362822. ***Best Paper in Education Innovation Award***

10) **Virtual Urbanism: A User-Centered Approach**

Mónica Vanesa Sánchez-Sepúlveda; David Fonseca; Jordi Franquesa-Sánchez; Nuria Martí-Audí, In XIII CTV 2019 Proceedings: XIII International Conference on Virtual City and Territory: Challenges and paradigms of the contemporary city. UPC, Barcelona, October 2-4, 2019. Barcelona: CPSV, 2019, p. 8430. E-ISSN 2604-6512. DOI http://dx.doi.org/10.5821/ctv.8430

11) **Methodologies of Learning Served by Virtual Reality: Case Study in Urban Interventions**

Mónica Vanesa Sánchez-Sepúlveda; Ricardo Torres Kompen; David Fonseca Escudero; Jordi Franquesa-Sánchez, Applied Sciences (CODEN: ASPCC7). ISSN: 2076-3417, Accepted:25/11/2019; Published:28/11/2019. Vol. 9 (23), 5161, DOI:10.3390/app9235161, JCR Q2, SJR Q1.

2 Theoretical Framework

2.1 Urbanism in theory and practice

The field of Urbanism is an important part of the sustainable development and has an immediate effect on the challenges that society is facing. Cities are at the forefront of global socio-economical change. Half of the world's population now lives in urban areas and the other half increasingly depend upon cities for economic, social, cultural and political progress (Cohen, 2006). How can we create sustainable, inclusive and creative cities in today's urban age? This is not about good urban amenities.

Urbanists also need to take fully into account migration, integration, cultural diversity, environmental management, easy access to services, protection of natural resources, sustainable urban water supply, more efficient energy and a full spectrum of cultural activities that acknowledges and embraces diversity. It is envisioned, to catalyze a cultural shift in the Schools of Architecture, breaking the partial vision of sustainability and moving to a new paradigm with the goal that future graduates act as agents of change to solve the challenges of our society.

One of the reasons this study focuses on Urbanism courses is because it is less studied than Architecture Design courses and its scale of impact. Most of the studies published about education in Urbanism in Europe are not updated and must be reviewed. Therefore, the following bibliography and reflections are taken into consideration for their contribution to this subject.

The chosen theme for the number 2 of *Ciudades* (Muzio, 1995) is the teaching of Urbanism in the Architecture schools, from a European perspective. Is composed of three articles with the opinion of Spanish professors and four foreign professors, each referring to their own country. Ten years after, almost the same title was given to the number 10 of *Urban* (De Terán & Sánchez de Madariga, 2005). *Un Urbanismo Docente* (Font Arellano & Lopez De Aberasturi, 2009) not

too far from this point of view, grouped professors and professionals of Urbanism with the purpose of explaining the ways of intervening and imparting the teaching of the Urbanism for the last thirty years. Among the reflections of these books and articles, the main ones are:

- Integration and inter-disciplinarily:
    - The possibility of a reorientation of the teaching towards a culture that considers the urbanism, architecture and landscape; and in which both the urban plan and the architecture project coexist.
- Actual problem-solving:
    - Abandoning the spatial model to the result of market forces, with the consequent renunciation of the comprehension of globality, limiting the intervention to the urban fragment where only morphological approaches can have room, implies to hinder the theoretical elaboration and in the long term the own advance of the urbanistic discipline.
    - The planning approach manifests itself in raising awareness about the cost of decision-making processes and on the need to provide an articulated response to citizen demands, as well as the social and environmental impact of the execution of plans. (this aspect is related to this thesis work).
- Culture and History Influence:
    - The influence of normative development on the delimitation of a professional field so narrow for architects has led to distance from the practice of urbanism. The limited cultural and urban training of the architects is a cause added to this distance.
    - The problem of employment or unemployment in relation to architects and/or town planners is not considered in all articles, despite the controversy over their structural condition, in view of the future reorganization of the profession. Absent in the articles of Spain and Italy is central in those that analyze the case of Germany and Great Britain, in which it is related to the search for a greater professional qualification.

- Lack of actualization:
    - The "classic" experiences have been losing their validity without being renewed or replaced by recent experiences that can be considered new models. (this aspect is related to this thesis work).
    - The “adjectivation” of the urban environment is a symptom of the current contradictions, in which an implicit renunciation to the global understanding of the urban phenomena is manifested.

These reflections lead to consider practical learning as a necessary complement to the studies and their sustainability and chains to consider professional structuring and the study of sustainability in the education of Urbanism. *Urban Design* (Krieger & Saunders, 2009) is taken for reference to study from the origins of the discipline. It is important to understand the history to know what is the main necessity of this discipline, the competences that are needed for the practice, the actual gaps in the discipline and opportunities to make it sustainable.

To understand the gaps and opportunities to make the discipline of Urbanism sustainable and to rethink urban engagement, a reference that is studied is *Urban Sustainability in Theory and Practice* (P. James, 2014). By identifying the key aspects of transformation towards sustainability at University, some cases from seven universities world-wide are studied (Ferrer-Balas et al., 2008). Some of the main findings and that are related to this thesis are:

1) The main barrier to overcome is the lack of incentive structure for promoting changes at the individual level. The main drivers for change are the presence of “connectors” with society, the existence of coordination bodies and projects, and the availability of funding, all of which are important for progress.
2) Enhancing interdisciplinarity is a strategic objective at almost all of these universities, while transformative learning is less present.
3) A common characteristic for most of the institutions is establishing and supporting networks of expertise within the universities.

4) The University, as an institution dedicated to the creation and diffusion of knowledge through research and teaching, plays a leading role in the dissemination and application of possible solutions and alternatives to the social, economic and environmental problems facing current society.

In the Spanish context, in September 2002, the Conference of Rectors of Spanish Universities (CRUE) approved the proposal for the creation of the Working Group on Environmental Quality, Sustainable Development and Risk Prevention in Universities (CADEP), currently Commission Sectorial CRUE-Sustainability (CSCS). The purpose was to promote initiatives related to risk prevention, management, participation and environmental awareness in universities, as well as inter-university cooperation in these matters.

The CSCS approved in 2005 the document "Guidelines for the Introduction of Sustainability in the Curriculum" in Universities. This text, prepared by the Working Group on "Curricular Sustainability" (GTSC) of the CSCS, proposes general criteria and recommended actions for the curricular sustainability in the Spanish University System (SUE). This process (CADEP-CRUE, 2012) involves a change in curricula to provide students with the transversal skills necessary to:

1) Understand how their professional activity interacts with society and the environment, locally and globally, to identify possible challenges, risks and impacts.
2) Understand the contribution of their work in different cultural, social and political contexts and how they affect the same and the socio-environmental quality of their environment.
3) Work in multidisciplinary and transdisciplinary teams to solve the demands imposed by socio-environmental problems derived from unsustainable lifestyles, including proposals for professional alternatives that contribute to sustainable development.

4) To apply a holistic and systemic approach to the resolution of socio-environmental problems and the ability to go beyond the tradition of decomposing reality into disjointed parts.
5) Participate actively in the discussion, definition, design, implementation and evaluation of policies and actions in the public and private spheres, to help redirect society towards a more sustainable development.
6) Apply professional knowledge in accordance with ethical principles and universal ethical values that protect human rights.
7) To collect the perception, demands and proposals of citizens and allow them to have a voice in the development of their community.

The GTSC has detected the difficulty of professors to integrate these concepts in the different subjects, regardless of their area of knowledge, since it requires an interdisciplinary and innovative practice (Barrón et al., 2010). Recent studies show the efforts to implement sustainability in Higher Education, but it is an area of research and emergent action, in which the lack of common criteria on the competences to integrate, their promotion and evaluation in University degrees still constitute a limitation (Ferrer-Balas et al., 2008; Lozano, 2011, 2014; Segalàs et al., 2009).

Therefore, it is important the redefinition of the studies of Urbanism in relation to the demands of society, the environment and the progress of pertinent situations. These suggested changes allow defining a frame of reference for common reflection. The discipline of Urbanism needs a commitment to reality and confrontation with the society to which it belongs, without renouncing its ability to propose independently of the apparent demands of the market.

2.1.1 Urbanism as a Discipline

Urbanism is an old practice, which had brought together a multiplicity of professionals: architects, economists, geographers, engineers, sociologists and urban planners. However, Urbanism as a profession is relatively new. Its theoretical maturity was reached in the twentieth

century, like a combination of different disciplines that were merged to rethink the city and build the discipline of Urbanism. We can take some interesting extracts from The First Urban Design Conference (1956) where people engaged in thinking about the future cities. Different authors participated in this Conference, like Jane Jacobs, Edmund Bacon, Lewis Mumford and several leaders of the soon-to-be-formed Team 10, that narrated about the origins and intentions of the discipline (Krieger & Saunders, 2009):

- Jose Luis Sert (Figure 3 Left) said, "…Meanwhile, city planning has developed as a new science; city planners today are concerned with the structure of the city, its process of growth and decay, and the study of all the factors— geographical, social, political, and economical— which have shaped the city." It was a time when specialists in the field started to study more about the problems of our cities adopting new methods of research and analysis, emphasizing the scientific phase more than the artistic one. "This may be due to a natural reaction against the past practice when city planning was based on the superficial "city beautiful" approach, which ignored the roots of the problems and attempted only window- dressing effects."
- In the same line, Edmund N. Bacon (Figure 3 Middle) said, "…We have the three principals: planning, architecture, and administration. What we lack is the capacity to function as a whole. Architects have fashioned almost the entire extent of their resources on the designing of individual buildings. The planners have tended to confine their efforts to the creation of broad and un-material concepts such as zoning, land-use control, density standards, and criteria. The administrators and policymakers, who really set the basic form of the urban environment, commonly regard the architectural aspect as something you purchase at the end."
- Eric Mumford relate the emergence of Urban Design in the Breakup of CIAM (Figure 3 Right) refer to the conception of the architect-planner: "someone who could organize the "mutual relation of parts" involved in urbanism instead of focusing on the design of any individual part."

Figure 3: Left: The 2006 issue No. 24 of Harvard Design Magazine celebrates the 50th anniversary of the Sert conference. Middle: Edmund N. Bacon in the cover of Time Magazine, Nov. 6, 1964. Right: The CIAM Discourse on Urbanism 1928-1960 (Eric Mumford, MIT Press, 2002)

Something common with these asseverations is the linkage with other disciplines like geography, anthropology, ecology, architecture, psychology and sociology that are all under the umbrella of the relation human-environment. The tension between objective and subjective explanations is one of the fundamental keys that operate in the different disciplinary approximations.

The objectivism emphasizes the role of the environment like the configurative object of the human being, and el subjectivism the role of the human being like a sensible subject, active or modifier of the environment (Romañá Blay, 2004). It is about finding rules or patterns adequate to each society or group of humans.

In the book *Urban Spaces, Public Spaces* (Carmona et al., 2010) asserts that in Urbanism are four significant themes: (1) is for and about people; (2) the value and significance of 'place'; (3) operates in the 'real' world, with its field of opportunity constrained and bounded by economic (market) and political (regulatory) forces; and (4) the importance of design as a process.

Other specialists in this discipline as Manuel de Sola-Morales describe three main aspects: permeability, sensuality and respect. Among others theorist that attempts to identify the

desirable qualities of a successful framework, is also Kevin Lynch that identified five dimensions: vitality, sense, fit, access and control. It can be said that it is about constructing a scenario for urban evolution, imagining the conditions of transformation and proposing a process capable of incorporating new experiences. But, how has it evolved?

In the book *Public Places, Urban Spaces* (Carmona et al., 2010), describes three historical eras where the cities and settlements have evolved through marketplaces, centers of industrial production and centers of service provision and consumption. At present, it is a merge of the three, but with a greater degree in service production and consumption. It presents the diversity of contemporary urban development processes and urban design ideas:

- Traditional urbanism (Figure 4 Left): grids, public squares, moderately dense housing and pedestrian corridors. Based on a critique of the ‘placeless-ness’ of the modern vehicular city and urban sprawl, it attempts to recover what it regards as a more 'authentic' urban framework.
- Conceptual urbanism (Figure 4 Middle 1): adopts a more radical attitude, mix the assumptions of ‘what the city was, is or should be', and welcome 'fluid instabilities' of cities as well as their 'inertia of material residue'. Instead of denouncing the 'chaos and congestion' of contemporary urban life, it 'experiment out from disruption and disorder'.
- Marketplace urbanism (Figure 4 Middle 2): ‘immense financial, technological and political energies’ emerging at ‘those nodes of dynamic intensity merging around the intersections of major freeways, on thousands of acres of farmland or wasteland, on the borders of existing cities’.
- Social urbanism (Figure 4 Right): a critique of most aspects of contemporary US cities, like the 'uneven consequences' of commodity capitalism. Highlighting areas of the city that 'capital ignores’.

Figure 4: Left: Traditional urbanism. Middle 1: Conceptual urbanism. Middle 2: Marketplace urbanism. Right: Social urbanism.

Traditional urbanism and conceptual urbanism suggest contrasting ideas. Marketplace urbanism is about the forces shaping the contemporary urban form, while social urbanism is a critique of the contemporary urban condition. How will the future urbanism be different from now? We do not know yet. William Mitchell argued, "The impact of the digital revolution will redefine the intellectual and professional agenda of architects, urban designers, and others who care about the spaces and places in which we spend our daily lives" (Mitchell, 2000). Not far from what we are living now, as he said this on 2000. This, together with global warming, contamination, urban sprawl, among other new variants, may also provoke radical change. Urbanism is not a passive reaction to change, but a relationship between the physical characteristics of a city, and its functional, socio-economic and environmental qualities (Carmona et al., 2010).

How is the discipline of Urbanism nowadays? The deep physical, social and cultural changes that we are experimenting force the contemporary Urbanist to a process that opens to recreate the discipline. Even processes that are now a common instrument, like the computer, have opened a new world to the Urbanism, through new forms, new perspectives and new ways of analyzing data. However, these possibilities have provoked questions about the nature of the urban project, about the way it manages the synthesis of the analysis and the compatibility between the physical, mental and social order.

The practice of Urbanism is opened to the processes of socially responsible participation and the conscious interaction of the culture that lives in each place. Psychosocial and post-

occupational studies, new communication media, ways of collecting data and technology that can detect social, economic and environmental patterns of the urban spaces are supporting the discipline and bringing another dimension to the practice.

Urbanism as a discipline has secured its place among the other established built environment professions, addressing interdisciplinary concerns. It is a policy and practice base discipline which, like architecture and urban planning, benefits from an extensive and legitimizing theoretical support. While Urbanism continues to evolve, it can be seen the different approaches that have been a catalyst for its transformation. Evolving from aesthetic, that concern with the distribution of building masses and the space between buildings, it has become primarily concerned with the quality of the public realm, both physical and sociocultural (Carmona et al., 2010). Urbanism is concerned with the structure, process of growth and decay, and the factors —geographic, social, political, and economic—, which have shaped the city (Krieger & Saunders, 2009).

Urbanism as a process was fruit of a culture to transforms a reality, a place, to make it more habitable which embraces different disciplines at the same time to understand the logic of the territory. What was missing was a synthesis. The professionals able to cover different aspects of the cities already existed, but who could interpret and organized all of them? It is then when the term Urbanism was born. Not to see the city as individual parts but a body. Therefore, it is interpreted that the training of the Urbanist does not separate the parts in specific courses but relates their parts in developing inter and transdisciplinary projects on social, environmental and economic problems.

2.1.2 Urbanism as a Subject

We can define Urbanism as a group of empiric technics which objective is to order the cities and for extension the territory — this last thing because of the existing distinction between the city and suburbs. This group of technics has theory support that synthesized the knowledge of

a group of disciplines of scientific character (geography, sociology, economy) or technic-artistic (architecture, civil engineering).

More recently, Urbanism has established interrelation with others, like political sciences (as Urbanism is a key instrument in the government of the territory) and ecology (because of taking care of the sustain of environmental quality in the processes and types of urbanization). As a discipline, with a spatial basic component, the practice of Urbanism in some countries, particularly in southern Europe, is related to the practice of Architecture (Ruiz Sánchez, 2002).

The practice of Urbanism has incorporated in its tools, aspects of management, every time more complex, that come from urban planning, where the components of spatial design is just a part. However, the tradition in one hand, with the necessity of maintaining the spatial component in the first plane, and the contrasting capacity of synthesis of knowledge and the proven ability to synthesize knowledge for its inherent implementation of architecture on the other, keep Urbanism as a field of dedication manly to the profession of the architect (Ruiz Sánchez, 2002). Still, Urbanism has an additional level of complication that forces the training of its discipline an approximation in its complexity.

From a sample of sixty schools in Europe study, it became apparent that, of the average total of teaching hours required for the diploma in architecture, Urban Education accounted for 7.6% (Spiridonidis, 2004). This reference ranks Urbanism in the curriculum as fourth in order of importance, after Architectural Design (33%), Building Construction (12%) and Theory- History (8.7%). Is this an appropriate percentage when architecture is the basic material for the construction of the city and the city is the social space in which all architecture is framed? If the construction of urban space is the goal of architecture within the city, therefore, architecture and city are linked. Probably, courses of Urbanism should have a higher percentage or linkage inside the curriculum and have better complementation in Architectural education.

The beginning of teaching Urbanism as a degree at the universities started to emerge because of courses offered in Europe and North America. In North America, the discipline of Urbanism began with the first formal North American programs in City and Regional Planning (1923) and Urban Design (1960) at Harvard University. This last one was born along with the texts on the subject published in that period, including (Figure 5): *Lynch's The Image of the City* (1960), *Mumford's The City in History* (1961), *Jacobs' The Death and Life of Great American Cities* (1961), *Cullen's Townscape* (1961), and *Bacon's Design of Cities* (1967).

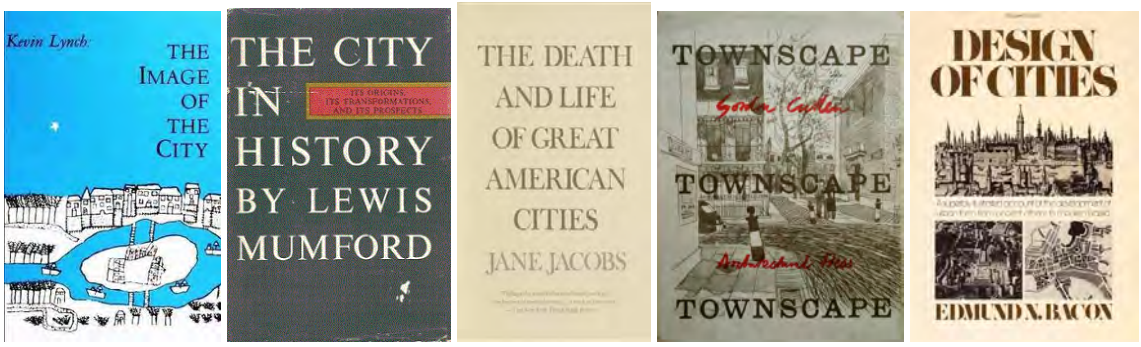

Figure 5: (left to right) Lynch's The Image of the City (1960), Mumford's The City in History (1961), Jacobs' The Death and Life of Great American Cities (1961), Cullen's Townscape (1961), and Bacon's Design of Cities (1967).

In South America, the studies of Urbanism are related with several events, like in 1944 when the Faculty of Architecture and Urbanism in Chile was created; and with the initiative of the Higher Institute of Urbanism of the University of Buenos Aires in the United Nations (1949) declared November 8 the World Day of Urbanism. In Europe, the crucial dates are when the first academic course on urban planning was offered by the University of Liverpool in 1909; when the Town Planning Institute was established in 1914 with a mandate to advance the study of town-planning and civic design; or when the first International Congress of Modern Architecture (CIAM) produced the Athens Charter started teaching about the urban planning based on the function in 1928; or also when the Department of Urbanism in the Faculty of Architecture at Delft University of Technology was established in 1948.

In the United Kingdom during the first decades of the twentieth century, Urbanism was configured as a profession linked to the physical and technical aspects of design. During World

War II, the work of Abercrombie in London and several reports commissioned by the central government created the Town and Country Planning Act of 1947, which enlarged the demand of urbanists and created a new labor market. The government commissioned the Schuster report, which transforms Urbanism from a drawing-based activity into an activity based on the social sciences, primarily geography, economics and sociology. This is part of the origin of the separation between Architecture and Urbanism in British education and training (De Terán & Sánchez de Madariga, 2005).

In France and Germany, with a lesser tradition of the Anglo-Saxon countries, where there have been degrees in Urbanism since the first decades of the last century, specific formations in Urbanism started to develop since the 1960s; also, with full-time formats during training periods of one to two and a half year. Comparable formations have also developed in Italy, although much smaller and much less diversified. Exceptionally in the United States and the United Kingdom, there are specific undergraduate degrees in Urbanism, for students without previous university degrees.

Both, in France and the Anglo-Saxon countries, there is a multiplicity of approaches in all these studies, and a clear differentiation between professional qualifications aimed at the training of researchers. In the Anglo-Saxon countries, the latter masters focused more on research than on vocational training are generally called Urban Studies, different from master's in Planning or Urban Design; in France, they are the "Diplomes d'Etudes Approfondies", DEA. In both cases, these qualifications can be obtained as an end itself or as an intermediate stage towards the attainment of the doctorate. In the latter case, the usual thing is that the credits obtained during the master or the DEA are considered as doctoral credits.

In Italy, the professions of architecture and engineering are protected by two associations, whose admission is obtained by passing state examinations. Architects and engineers have always demanded exclusive jurisdiction over Urbanism and have refused to accept new graduates in town planning. As a consequence, the paradox arose because urban plans could

be "signed" by chemical engineers or by architects specialized in interior design, but not by urban planners who had received 4 or 5 years of specific training on the subject (De Terán & Sánchez de Madariga, 2005). This takes away the validity of the profession and the training needed to practice it.

One of the consequences taken for granted is the disappearance of the traditional architect, and bets on a more specialized formation, which shares the idea of the architectural project as the starting point of all of them. “The European architecture directive establishes a minimum of four years, assuming that all the professional competences in force are acquired. If its acquisition is modulated - according to the sequence proposed by the EEES - the degree could give rise to a basic architect, with competences in the field of housing; the masters, to specialists with competences in the traditional fields of work of the architect: building, urbanism and design, and the third cycle, to graduates with training in subjects of high specialization” (De Terán & Sánchez de Madariga, 2005).

By studying more in detail different models of Urbanism as a Subject in Europe, it was studied some characteristics about each country to make a comparison. The information used for this part is taken from bibliography date from 1973 (Solà-Morales Rubió et al., 1974), 1995 (De las Rivas Sanz, 1995), 2003 (Monedero Isorna, 2002) and 2005 (Hernandez, 2005). From the comparison made it is concluded that the United Kingdom for their long tradition worrying about the study of the Town Planning has managed to incorporate new ideas and tendencies in such field making the discipline more validated than in Central or Latin Europe. This has helped also in the integration of the government in recognition, association and subsidies. However, this has led to made Urbanism as a discipline of its own and a separation from the training of architects.

In the study plans for English Architecture Schools, Urbanism is integrated into other courses but not as specific courses, opposite to other countries like Holland, Belgium and Italy that have near 10% of their courses dedicated exclusively to Urbanism. It is also noted that especially in

Central-Europe has managed to integrate the discipline to two main backgrounds, civil engineers and architects, to cover the technical and more scientific area, something that for example in Latin-Europe is not common.

Comparing how Urbanism as a subject has developed and how it is approached in each country, it can be deduced that Urbanism is in constant questioning and the disjunctive between the artistic and creative attitude and the social attitude. Urbanism cannot use the plasticity of architecture nor to develop the paradigmatic causticity of economics, for example. All this, along with the role of universities, that if we consider the training that architect gets in Urbanism, the quantity in percentage is low and frequently called into question. Is not to the debate on the future of teaching in the strict sense, but it should be mentioned in this reflection the debate around the requirement of specialization for the practice, as it affects the conception of the higher technical school as an institution that must scientifically form the professionals with the adequate tools.

2.1.3 Urban Design Competences in Spain

Over the last decade, European Higher Education Area (EHEA), and institutions have been involved in a transformation process to create a common framework for mobility and generate a knowledge-based competitive society (European Ministers, 2001). As an objective of the educational reforms, it is promoted in these contexts that: “Higher education institutions should train students to become knowledgeable and deeply motivated citizens with a critical sense and capacity for analyzing the problems of the society, finding solutions for those who oppose to society, applying them and assuming social responsibilities”.

In Spain, universities are in the process of redesigning and verifying their qualifications following the new guidelines established for the EHEA. This change aims to put the student at the center of the teaching-learning process, focusing on the competences that the new graduate should possess, enhancing students' know-how, initiative and autonomous learning

(Initiative & Initiative, 2004). This new scenario creates a suitable context for the use of new ICTs in higher education, key tools in the development of these new competences.

As already predicted (Adell, 2006), the digitalization of information has changed the primordial support of knowledge and with it our habits and customs about knowledge and communication and, in the end, our ways of thinking. In this sense, new ICTs are changing the way to learn and the type of materials (Negroponte, 1996). If we analyze the incorporation of ICTs in teaching (Area Moreira & Area-Moreira, 2008; Píriz Durán et al., 2013), we can observe how universities are increasingly implementing new technologies as support for teaching, but still, there is a gap between the potential of their incorporation in classrooms and the unusual renewal of pedagogical processes. This is because the ICTs have been incorporated into our universities are often associated with individual teaching practices and not as a methodical change.

According to EHEA, within the basic competences and training that must be acquired in engineering and architecture degrees, we can identify the "Capacity of spatial vision and knowledge of graphic representation techniques, both by traditional methods of metric geometry and descriptive geometry, such as through computer-aided design applications" (Ministerio de Educación Nacional et al., 2013). In Spain, the academic abilities and competences for the architecture and the urbanism profession were defined by the White Book (*Libro Blanco*) for Architectural and Building Engineering studies, promoted by the National Agency for Evaluation and Accreditation. The main competences identified to develop are:

- Basic skills in computer use.
- Application of graphics procedures in the representation of spaces and objects.
- Representation of visual attributes of objects dominating proportion and computer techniques.
- Skills with spatial representation systems.
- Skills with graphic lifting techniques in all its phases.

These competences must be developed in a formal educational context: learning typically provided by an education or a training institution, structured and leading to certification (Clark,

2015). But in the architectural and urbanism courses is easy to work with real Project-Based Learning. Under the guidance of a tutor, students are required to develop a proposal, usually in a given location, in a process that mimics the workflow of an architectural studio. Adding to this training, architects and urban designers learn about their discipline continuously and informally, because the subject of their craft surrounds them almost anywhere and anytime. Learning results from daily life activities related to work, family or leisure, because the subject of their craft surrounds them almost anywhere and anytime (Bee & Analysis, 2003; Malcolm et al., 2003).

In Architecture studies, courses that include the design of the urban space consider that the relation between buildings makes possible the structure of the territory and the city as a whole, and that relation includes aesthetics, scales and strategy. This forces the architect to have urban training inside of the architecture student career (Monica V. Sanchez-Sepulveda, Franquesa, et al., 2018). The competences required for urbanism courses in Spain established on the White Book that aim of carrying out studies and useful practical cases in the design of a degree adapted to the European Higher Education Area (EHEA) that relate to the method of a virtual interactive system are:

1. Ability to understand the relationships between people and buildings and between buildings and their surroundings, as well as the need to relate buildings and spaces between them based on human needs and scale.
2. Capable of making decisions (in projects, construction systems, organization, etc.).
3. That students know how to apply their knowledge to their work or vocation in a professional way and have the skills that are usually demonstrated through the elaboration and defense of arguments and the resolution of problems within their area of study.
4. That students can transmit information, ideas, problems and solutions to a specialized and non-specialized public.
5. Acquiring self-critical capacity.

6. Aptitude or ability to apply the basic formal, functional and technical principles to the conception and design of buildings and urban complexes, defining their general characteristics and benefits to be achieved.
7. Aptitude or ability to develop building programs, considering the requirements of customers and users, analyzing precedents and location conditions, applying standards and establishing dimensions and relationships of spaces and equipment.
8. Aptitude or ability to design and execute buildings and urban spaces suitable for people with different physical capacities or to adapt existing ones for this purpose.
9. Understanding or knowledge of the methods of study of the processes of symbolization, of ergonomics and the relationships between human behavior, the natural or artificial environment and objects, according to human requirements and scale.

Regardless of the competences' requirements in each academic institution that may slightly vary, the list above represents general competences in the field that are considered. The base of the training in urban design aimed at developing the ability to identify problems and devise solutions, through an understanding of the complex processes that affect planning, using different methods for solution design.

2.1.4 Formal vs Informal Education

Usually, most educational systems are designed in a regulated manner, i.e. within an educational environment and formal student training (David Fonseca et al., 2016). However, in recent decades, there have been studies and research that emphasize the importance of other forms of education away from schools, regardless of the level (Harrop & Turpin, 2013; Jamieson et al., 2005; La Belle, 1982). Learning processes are not only confined to regulated areas but also non-formal or informal ways are present throughout a person's lifetime. To do so initially we must clearly differentiate between all types of education currently defined (Coombs, P.H.; Prosser, R.C.; Ahmed, 1973):

- Formal education: Learning typically provided by an education or a training institution, structured and leading to certification.

- Non-formal: Any organized educational activity outside the established formal system.
- Informal: Learning resulting from daily life activities related to work, family or leisure.

In the base of these definitions, the architectural education allows incorporating, in a complementary way, non-formal educational elements, such as specialized courses, as well as informal education. Formally, in Architecture Schools, the Urbanism course has traditionally relied on Project-Based Learning. Throughout this process, students learn to integrate often-conflicting aesthetic, constructive, structural, environmental, and usability requirements into a cohesive design (Francesc Valls et al., 2017). Adding to this training, architects and urban designers learn about their discipline in a continuous and informal way, because the subject of their craft surrounds them almost anywhere and anytime.

Informal data related to a public space that analyzes semantic, temporal and spatial patterns, aspects generally overlooked in traditional approaches, improve the education of future urban designers in order to relate the projects to the main needs of the citizenship (Francesc Valls et al., 2017). Through digital transformation, students and future urbanists should be able to incorporate informal data obtained from the space, its functionality and the needs and the interests of citizens, to develop more sustainable projects and products adapted to more users and/or users with different profiles or disabilities.

The need to incorporate an informal approach to the education of areas whose projects are to be used by the public is essential. The views of users are not only basic but provide information that the student should be able to assimilate into their education to improve the acquisition of skills and competences described in their academic plans. The informal feedback in the training of the urbanist is undoubtedly one of the determining factors of the project. In the case of the urbanist, an intangible formation should allow improving his future projects. Therefore, gamification, based mainly on behavioral theories, focuses on enhancing observation (response to stimuli), feedback cycles (knowing where I am and what little remains are missing), and reinforcement for rewards (learning appears by the stimulus).

2.1.5 Difficulties and Opportunities

After many years of individual, isolated work of architecture, -landscape architecture, road engineering, and city planning, that developed independently-, we are logically coming to an era of synthesis to solve urban design problems, previewing the discipline of an architect-planner-administrator, as one profession to solve the urban situations from small details to its whole. The urbanist as a profession was born with a clear social responsibility that implies harmonizing all the components that affect and are affected by the built environment. There was a need to have a professional that could understand different aspects that affect the urban form, social life, environment and economics. It is then necessary for the urbanist to be trained in these general aspects in accordance with the history, actuality and tendency of the place.

Often, the modification of the political and economic situation is insufficiently reflected in this type of technical conception of applied Urbanism. An option to be contemplated is for Universities to become the place where urban plans are approved or rejected, models such as the ban on city expansion, an idea that is initially considered counterproductive and unrealistic to limit the consumption of surfaces for residential use, for example. Urbanism in Higher Education is an opportunity to invite students to meet, comprehend, integrate, and compose knowledge, theories, and corroborations related to the city as a cultural, social, and economic fact. It is a platform to produce outcomes related to social life in the built environment, to the cultural dimensions of the form and organization of urban space.

The point of studying the teaching of Urbanism in Architecture Schools is because it is considered that the dialogue between buildings makes possible the construction of the territory and the city as a whole, and that necessary dialogue from aesthetics, scales and strategy. This forces the architect to have an urban formation. As it was seen, Schools put more or less weight on this matter, as not all of the students will practice as urbanists in the future and what is needed is a general conception, to, later on, if desired, make a specialization. Then, knowing that Schools of Architecture, where Urbanism does not constitute a profession with its own entity, and the architects are the urban planners, means that Urbanism should not be

taught as an "urbanism for architects" but, with all its implications. Therefore, the role that corresponds to urbanism in the teaching of architecture cannot be a mere secondary role, subsidiary of architectural projects. What does seem clear is that all architects must acquire this global vision, since all, whether or not they do postgraduate studies, as in fact they are urban planners.

2.2 Adapting Architecture Learning with Technologies

2.2.1 Learning Processes in Undergraduate Students

Any research in the educational field should start by considering how students learn. Ambrose (Ambrose et al., 2010) states that learning is a process and not a product, but since this process takes place in the mind, it can only be assumed that it has taken place by analyzing changes in the learners. Whenever a professor designs a class, the first issue that must be considered is the audience.

The nature of students—their academic preparation, aspirations, and cognitive development—affects the professor's elections on what and how to teach. The focus should not be on the teaching of the specific contents of the subject (such as physics, Spanish, mathematics, art, and so on), but on the students as an audience (Nilson, 2010); this requires an understanding of how the human mind learns. There are certain kinds of delivery that are more effective in terms of communication than others, meaning that they make it easier for people to pay attention, remember and grasp concepts, and process information and knowledge (Nilson, 2010).

Centuries of teaching at University level have been characterized by an audience of students taking notes from a professor delivering authoritative lectures to later test students on their knowledge and assign grades (Davis, 2009). However, over the past thirty years, research on theories of learning and cognitive development and students' academic success has confirmed that teaching that emphasizes active learning and collaborative activities, and that promotes intellectual engagement on students, is more efficient. Professors interact with students in

ways that allow the latter to obtain new information, practice new competences, and rethink and expand on what they already know. Other relevant concepts provided by previous studies (Nilson, 2010), that will also be taken into account in this study, focus on several characteristics of human beings. According to these studies, they are as follows:

- Are innate learners, capable of remembering and absorbing uncountable details about objects and other people (Bransford et al., 1999; Spence, 2001)?
- People learn by connecting new information to what they already know (Bransford et al., 1999; Tigner, 1999).
- People learn what they consider relevant to their lives (Miller, 2007).
- People learn informally by building knowledge in social groups (Stage et al., 1998), but also learn individually and in one-on-one situations (Spence, 2001).
- People learn when they are motivated to do so by receiving encouragement from other people in their lives (Feldman, 1997).
- People do not learn satisfactorily when their main learning environment is professor-centered, and it requires passively listening while the professor talks. Human beings cannot pay attention for long when their brain is in an inactive state (Bligh, 2000; Bonwell & Eison, 1991; Hake, 1998; Jones-Wilson, 2005; McKeachie & Hofer, 2002; Miller, 2007; Spence, 2001).
- People learn more when they obtain new material several times by using diverse methods, which require the use of different parts of their brain (Jewitt et al., 2001; Tulving, 1985; Vekiri, 2002).
- People learn when they actively examine their learning and performance (Bransford et al., 1999).
- People learn less by going through the material and more from being examined by others or themselves on it, as it implicates more cognitive processing and requires them to practice retrieving information (Dempster, 1996, 1997; Roediger & Karpicke, 2006).
- People learn more when the material helps stimulate emotions and not just intellectual or physical involvement (Leamnson, 1999, 2000; Mangurian, 2005).

For most people, part of the value of a career in academia is the chance to help learners in their path to becoming future professionals in the field and share their enthusiasm with others; for this reason, it can be discouraging for them to look into a classroom and see disengaged students. This lack of engagement and motivation happens mostly when it is hard for the learners to connect what they are learning to existing knowledge; when they are learning passively and individually; when the information is explained just one time or in only one way, making it more difficult to understand its relevance; and when the material does not evoke emotions and does not produce an action-reaction experience. For students to understand the concepts being presented to them, it is crucial that they are engaged. The more the student is engaged in academic work, the greater the level of knowledge achievement and general cognitive expansion.

Biggs (Biggs, 2003), mention two types of students: the "good" student—intelligent, well prepared, goal-oriented, and motivated to master the material, that came to college with solid thinking, writing, and learning skills. This type was about 75 percent of the students in 1980 and only about 42 percent are like that today (Brabrand et al., 2006). The rest 58 percent are less academically talented, college-ready, and motivated to learn, that just wants to get by with the least amount of learning effort, so they can parlay their degree into a decent job. This type of student will rely on memorizing the material rather than reflecting on and constructing it (Brabrand et al., 2006). In different generations, there are both types of students that Biggs describes. The only thing that changes is the percentage.

Good teaching, according to Biggs, is obtaining the maximum of students to use the higher cognitive level processes that the majority of students use spontaneously (Biggs, 2003). How is the cognitive process of undergraduate students? William G. Perry (Perry, 1970, 1988), and Baxter Magolda (Baxter Magolda, 1992) came out separately with theories on the cognitive development of undergraduates. The stages can be summarized in four types of how students begin the university with a duality perspective and may, varying on their instruction, progress throughout the stages of relativism, multiplicity and commitment and four levels of knowing: independent, absolute, transitional and contextual (Figure 6).

Perry's Stages of Undergraduate Cognitive Development	Baxter Mogolda's Levels of Knowing
3. Relativism: All opinions equal • Standards of comparison	Independent Knowing
1. Duality: Black and white thinking; authorities' rule • Uncertainty	Absolute Knowing
2. Multiplicity: Poor authorities or temporary state • Uncertainty as legitimate, inherent	Transitional Knowing
4. Commitment (tentative) to best theory available	Contextual Knowing

Figure 6: Stages/Levels of Student Cognitive Development (Nilson, 2010).

Position 1, students perceive the world in black-and-white. They choose what to accept as true and how to act according to standards of right and wrong. Authority figures, like instructors, theoretically know and teach the absolute truths about reality. Knowledge can be enumerated like exact answers on a spelling exam. Position 2, students enter the stage of multiplicity. They realize that since instructors do not know everything there is to know, a discipline permits several views to compete for acceptance. Students don't give these views much credibility, believing to be just an instructor's exercise intended to lead them to the one correct answer (Nilson, 2010). Position 3, the stage of relativism, students take away their faith in the instructor's capacity to recognize the truth and have no hope of there ever being one true explanation or solution. Students at position 4 feel the need to position themselves in their relativistic world by making like a personal commitment to one posture or another. They experience and study the effects of their election of responsibility, understanding the individual and intellectual growth.

Knowledge is constructed based on personal experiences and hypotheses of the environment. Learners continuously test these hypotheses and have a different interpretation and construction of the knowledge process. A reaction to didactic approaches such as behaviorism and programmed instruction, according to (Piaget, 1970) and (Valero García, 2013) states that

learning is an active, contextualized process of constructing knowledge rather than acquiring it. People learn by inserting information into their cognitive structures and reorganizing these if necessary.

The form (a) (Figure 7) represents the cognitive structure that each person has. Each node is information and the bridges are the relationships that people have established among this information, from their living experience. Learning occurs when someone (teacher, book, television, etc.) throws a ball of new information against the learner's cognitive structure. A simple way to explain the construction of learning is shown the Figure 7:

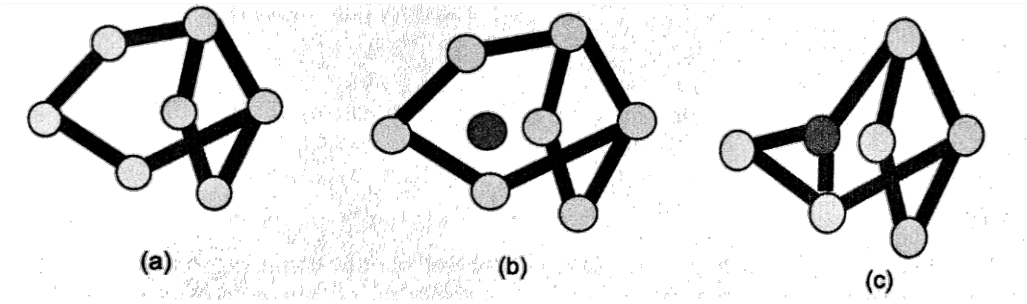

Figure 7: Construction learning theory. (Valero García, 2013)

With that ball can happen three things:

1) The ball does not touch any element of the cognitive structure and navigates it without changing it. In this case, no learning occurs, because the ball does not put on question what the learner already knows. (a)
2) The ball does not hit any element of the structure, but the learner holds it artificially, for example, until the day of the exam, in case it is useful. After the exam, the learner let the ball go. In this case, there has been no learning either. (b)
3) The ball hits against some element of the structure and destabilizes it. The new information puts into question part of what the learner believes and can no longer continue to believe. The learner reorganizes the structure, remakes the relationships, integrates the new information and distributes others that are no longer relevant. In this case, learning has occurred. (c)

There are many theories on the strategies of teaching for the student to "grab the ball" of information as part of their cognitive structure and do its work. (Valero García, 2013) speak of among others of two principles of quality teaching:

1) Stimulates active learning.
2) Provide feedback on time.

According to other relevant ideas provided by previous studies (Nilson, 2010), effective methodologies of learning combine different aspects:

1) Begin where the students are, their lifestyles. Then relate to it the new content. This helps them learn from what is familiar to them, both cognitively and experientially.
2) Make the material relevant to the students' day-to-day experience, future careers and real-world problems.
3) Use active learning techniques, and when lecture, do it interactively, with frequent breaks for student activities.
4) When possible, use experiential methods: those that place students in real-life problem-solving situations, simulated or genuine.
5) Teach in multiple modalities. Give students the opportunities to read, hear, talk, write, see, draw, think, act, and feel new material into their system. In other words, involve as many senses and parts of the brain as possible in your teaching and their learning.

According to these principles and the theory of levels, ways of learning and current undergraduate architecture student's profile we can conclude three main aspects:

- Students evolution from when they start and finish in their undergraduate degree, the reason why the way they react will vary according to their age. By this is meant that students at the beginners' level are into what they know, and at a more advanced level is more open to admitting different options.
- When new options are given related to what the learner already knows is easier for them to associate and learn from it than when it has nothing to be related. Meaning

that using methodologies associated with their lifestyle could facilitate learning.

- To stimulate the student to learn it must be active and with the involvement of many senses, relevant and associated with their lives and that they can see the immediate result of what they are doing. Meaning that having real-time systems can facilitate students to see immediate results of their work.

2.2.2 Current Architectural Students Profile

Learning can occur without teaching but unfortunately not the other way around. The student builds their mind by constantly making, changing connections between what is new, and what is already known in a dynamic process. Teaching in this Digital Era, a time so related to computers, the different learning methodologies are immense, plus people prefer to learn, in different ways: hands-on activities, reading and writing, watching demonstrations and videos, and still others by listening to a lecture (Rachmatillah et al., 2019). These entire preferences key to the different ways people learn most easily, commonly known as learning or processing styles. Should instructors then teach their material in different ways to accommodate these different styles? Probably they should prepare students for life in the real world by not giving them special treatment. However, knowing and being able to take advantage of students' learning-style strengths also helps instructors prepare them for the real world.

Nowadays, the students who already have access to the university can be defined as Digital Natives (Margaryan et al., 2011; M. Prensky, 2001) or Digital Residents (White & Le Cornu, 2011), because they coexist and use all kinds of network technologies, multiple applications and all kinds of mobile devices at very early ages. They live and use from very early ages all kinds of network technologies, a variety of applications and types of mobile devices. In addition, these students already in their High School have used the Information and Communication Technology in their learning, both through digital platforms and in the use of multiple programs and computer applications, such as in the use of the Internet as a source of information.

This generation are the students that were born in the mid-1990s, early 2000s. They were raised, combined with the school experience, along with their heavy mass media exposure, made them self-confident, extremely social, technologically sophisticated, action bent, goal-oriented, service or civic-minded, and accustomed to functioning as part of a team, but on the other side, they are also impatient, demanding, stressed out, sheltered, brand-oriented, materialistic, and self-centered (Nilson, 2010). This characteristic has a lot to do in the way they perceive the instructor, the institution and education. This generation has an increased use and familiarity with communications, media, and digital technologies, something older generations did not. However, it must be said that the characteristics of this generation do not apply an entire generation but a portion of its members, as the characteristics vary by region, depending on social and economic conditions.

Students are typically more motivated to engage with material that interests them or has relevance for important aspects of their lives (Ambrose et al., 2010). It is better to assign problems and tasks that allow students to see the relevance to their current academic lives. Students sometimes do not appreciate a current learning experience because they do not see the value or do not recognize how the skills and abilities that they develop across courses will benefit them in their professional lives. Whatever the methodology is used, it is important to understand that the students are not one type or another but use multiple learning strategies and rely on multiple input modes.

A lasting learning experience must be moving enough to motivate people to want to learn it. The structure does affect —increases or decreases— learning. It is not about the information given but the knowledge that is share. Information can be found everywhere and more nowadays with internet access. Academics must offer what information-packed websites do not. Instead, must offer that structured set of patterns that have been identified through observation, followed by reflection and abstraction (Kuhn et al., 1970). It is important to help students see the difference between information and knowledge, to put in practice critical thinking structures that the discipline uses. These thinking processes will help them identify

conceptual similarities, differences, and interrelationships while reducing the material to fewer, more manageable pieces (Nilson, 2010). The fewer independent pieces of knowledge the mind has to learn, the more knowledge it can process and retain.

Today's students want to learn differently from the past; they want to create, use the tools of their time, work with their colleagues for projects, make decisions and share control. They also want to share their opinions in class and around the world and above all want an education that is not only relevant but connected with reality (M. Prensky, 2010). For them the new era of Information Society (IS) is simply their era and therefore the acquisition of skills and knowledge, general and specific skills, must be related to the use and control of Information Technologies (IT) (Paes et al., 2017).

The use of ICTs in educational methods is defined in the curricula of many undergraduate and master's degrees, including the architecture degree (Reffat, 2007; Sariyildiz & Veer, 1998; Tinio, 2005). The adaptation of contents and their applications to ubiquitous learning in the fields of architecture, construction and urban design, all focusing on the student and their levels of motivation and satisfaction, has been studied recently (Sánchez Riera et al., 2015). From an academic viewpoint, these systems are used to improve the acquisition of skills and spatial competences to analyze the visual impact of any building or architectural project.

In architectural education, until recently, the use of ICTs was restricted to project implementation processes, where various applications such as CAD (Computer Assisted Design) and BIM (Building Information Modelling) served merely as aids in the execution of one's work, not as tools for the decision making of the architecture and urban planning project (Navarro, 2017). It is true that the new technologies that model in 3D, Virtual Reality and even videogames, represent progress to enhance the capacity of spatial and graphic vision and therefore facilitate the process of project conception (Martín-Dorta et al., 2008; Torner, 2009). Although they have the additional advantage of greater motivation and passion in learning and

could highly profit from this technology as a method of learning, until now, they have not been considered as tools for architectural design.

Which methodologies can universities profit from the current profile of the students and the technologies available to update the methodologies of learning? (Vrebos et al., 2019) In general, and even more for architecture students, graphic visuals are powerful learning aids because they provide a ready-made, easy-to-process structure for knowledge. For students is easier with visuals than with text (Nilson, 2010). As explained before, people learn best when they receive the new material in different ways, that is, through multiple senses and modes that use different parts of their brain, multiple-method instruction. Teaching to multiple methodologies can help revitalize lesson plans that have become routine through repetition (Abdullah et al., 2017; Dinis et al., 2017; David Fonseca et al., 2013; Wang et al., 2018).

Nowadays the world that surrounds us is increasingly digital, especially for the younger generations using mobile devices and cloud computing services (Moreira et al., 2017), and in the specific framework of the education and professional practice of Urbanism is necessary to incorporate this new paradigm and approaches.

One of the main motivations of university students is to be well prepared for their professional life and so they expect more courses to involve practical applications during their academic studies. Visual communication skills are connected to the competences required for professional practice. Architects should be able to choose a suitable representation medium, such as traditional graphics and digital technology tools, to communicate fundamental formal elements during each phase of the design process.

2.2.3 Visual Technologies in Architecture Education

Architects are trained to have the ability to build abstract relationships and understand the impact of ideas based on research and analysis, including the facility with a wider range of media used to think about architecture and urbanism including writing, research skills,

speaking, drawing and model making. Linked to these skills are the visual communication skills (Cho & Suh, 2019; János & Gyula, 2019; Lobovikov-Katz, 2019; Salerno, 2018). Throughout the history of architecture education, understanding and visualizing 3D spaces has been usually done using of drawings and physical models instead of 3D models and virtual visualizations (Monica V. Sanchez-Sepulveda, Fonseca, et al., 2018).

The debate about the growing incorporation of digital technologies in the design of urban spaces contains several interrogates related to the complex processes of transformation that affect cities, in the economic, social, political, and environmental aspects (Mónica Sanchez-Sepulveda, Fonseca, et al., 2019). Sectors, like the University, that are concerned in undertaking social challenges like unpractical city spaces, take benefit of the emergent technologies. The diffusion of ICTs is having a profound effect on the mode through which education moves forward, including the immersive interactive systems as a methodology of learning.

The use of these new methods is emerging because of generational change and the continuous development and improvement of technology (Francesc Valls et al., 2017). New technologies are transforming the way these processes are carried out. The world that surrounds us is now becoming progressively digital, in particular for newer generations that are technologically savvy and familiar with the use of mobile devices and cloud computing services (Moreira et al., 2017). The integration of this new approach and paradigm in the specific context of the education and professional practice of urbanism is crucial.

The use of ICTs in educational methods is defined in the courses of many undergraduate and master's degrees, including the Architecture degree (Reffat, 2007; Sariyildiz & Veer, 1998). From an educational perspective, these methods are applied to enhance the acquisition of spatial competences to analyze the visual impact of any architectural or urban project (Francesc Valls et al., 2017). Architecture students must learn to be proficient in these representation technologies throughout their studies (Navarro, 2017; Monica V. Sanchez-Sepulveda, Marti-Audi, et al., 2019):

- Basic Digital Applications. The study of spatial geometry is fundamental to enhance the development of reasoning and spatial ability. In this sense we can identify different type of tools:
  - 2Dimensions - 3Dimensions CAD (Computer Assisted Design) Systems: The CAD methods allow a fast representation and modeling of the architecture and urban data. Compatibility with technical modeling software allows adding specific modules on more powerful graphics platforms such as AutoCAD to manipulate 3D figures and spatial comprehension of the projects (Bénière et al., 2013).
  - GIS (Geographical Information Systems): One of the classical methods in the urban representation that allows linking the graphical elements with alphanumeric information to obtain an expanded analysis of the working area, for example, using topologies or thematic maps (Yeh, 2005).
  - BIM (Building Information Modelling): BIM applications can apply to the entire process of building construction. From the graphic conception to the physical realization. The improvement of the performance of the software has allowed the computer to be used as a drawing and also a support tool in the genesis of the project (Sayed et al., 2016) capable of integrally managing the 2D and 3D information of a Project.
- Multimedia Systems: The contents that are based on these formats are closer to the means of everyday use. For this reason, these types of systems are more attractive, increase the motivation and favor the performance (Martín-Gutiérrez et al., 2010). Communicating design intent and conveying space to non-technical clients has always been a challenge for architects. Immersive advancements such as virtual reality are paving the way for new ways to deal with this challenge enabling designers to jump into a 1:1, true to scale VR version of their 3D model. Interactive, spatial, real-time technologies can radically improve modeling and communication of ideas, enable participation in the design process, and facilitate planning and management at the urban scale (Whyte, 2003).
- Social and semantic data: Informal data related to a public space that analyzes semantic,

temporal and spatial patterns, aspects generally overlooked in traditional approaches, improve urban designers to relate the projects to the main needs of the citizenship (Francesc Valls et al., 2017). Through Digital Transformation, urbanists should be able to incorporate informal data obtained from the space, its functionality and the needs and the interests of citizens, to develop more sustainable projects and products adapted to more users and/or users with different profiles or disabilities.

- Videogames/Gamified Systems: Tasks that have a high spatial component (rotate, move, scale, etc.) are present in video games, as well as in serious games applied to the visualization of complex models, where we can find actions in which the user must move the character in a multitude of possible combinations. The use of additional devices (knobs, hand wheels, glasses, etc.) is considered to be a coordination of hands and feet with mental tasks (Gagnon, 1985; Sedeno, 2010). New interactive systems based on video game platforms, such as Unreal or Unity, capable of managing a visualization through Augmented Reality, or Virtual, in real-time, as the main advantage over CAD/BIM systems.
- Rapid prototyping and real models: Through the mode of contact, the use of real elements that can be manipulated helps the mental process of visualization. Physically you can rotate the object to see it from any point of view without having to do the mental effort (Navarro, 2017). You can physically rotate the object to see it from any point of view without the need for mental effort.

Architecture students tend to express primary by visual representation and throughout their academic career learn to represent through various representation technologies incorporating them in their design process to better communicate their proposals. Technologies that model in 3D, Virtual Reality and even videogames, represent progress to enhance the capacity of spatial and graphic vision and therefore facilitate the process of project conception (Martín-Dorta et al., 2008; Torner, 2009).

Architects should have the ability to use appropriate representational media, such as traditional graphic and digital technology skills, to convey essential formal elements at each stage of the design process (Malcolm Champion Taylor, 2008).

The contents that are closer to the means of everyday use of students and end-users are more attractive, increase the motivation and favor the performance (Martín-Gutiérrez et al., 2010). These interactive applications have favored the performance and speed of learning as well as the personal and intrapersonal skills of students. A few of these examples can be found in the compilation of (García, 2015).

2.2.4 Methodologies of Learning Served by Virtual Reality

As we have previously stated, ICTs have transformed our society and, consequently, education (Dede, 2000). The ways we now communicate have been adapting to new devices that mostly involve characteristics such as mobility, interaction and interconnection (Monica V. Sanchez-Sepulveda, Fonseca, et al., 2018). Studies (Bower et al., 2010) explain the openings obtainable by these emerging technologies as making a new type of reality, in which physical and digital environments are merged throughout our daily lives (Doyle et al., 1998; REDONDO et al., 2017). However, in education, this aspect still in the process of adapting to these changes. There are plenty of examples were the traditional lecture class is given as the predominant system and not profiting to the fact that this generation is capable of adapting and quickly using all types of devices and applications for their own purposes (Bennett et al., 2008).

Urbanism courses, inside Architecture Schools, usually tend to explore different aspects of the relationship between research and design through lectures and workshops, where students must actively engage in tasks proposed by professors and receiving feedback. However, drawing plans and urban planning do not tell us about the possibilities that can ponder the citizen participation and how they applied to the construction process of the city (García-Pablos, 2012). Emerging technologies are changing the way to conceive these processes.

Recent studies (Sánchez Riera et al., 2015) focus on the adaptation of contents and their application using ICTs in the fields of architecture and urban design, focusing on the student, and their satisfaction and motivation. From an academic perspective, ICTs enhance the acquisition of spatial competences to study the visual impact of urban or architectural projects. Particularly, in architecture and urban design courses, it is necessary to evaluate whether a design is appropriate before being built, leading educators to reconsider how students represent the designs and learn to make this evaluation. Thus, it is important that students develop skills in various representation technologies, and can integrate the latest technologies in their design process, with the aim of better communicating their proposals, and to facilitate analytical thought on the spaces they design (Suwa & Tversky, 1997).

In education, mixed reality (MR) is a new approach that transforms the way students deal with information. MR technologies, namely virtual reality and augmented reality are used in architectural and urbanism research and practice to support the design process, to visualize design alternatives set in existing built environments, and to assess people's reactions to their living environment. Virtual reality is a combination of technologies used to visualize and provide interaction with a virtual environment. The variety of settings in which VR could be used to represent make it largely relevant to many areas in education. An important characteristic of VR is that it allows for multi-sensory interaction with the space being visualized.

The combination of multi-sensory interactivity makes VR ideally suitable for efficient learning, as it benefits from the advantages provided by active learning through experiences, which is the main reason why we choose this system for this case study (Bekele & Champion, 2019). Virtual reality is broadly used in the industry and is starting to be more affordable for users. AR and VR share features like interaction, navigation and immersion (Christou, 2010); AR may be defined as a VR variation in which the user can see virtual objects mixed or superimposed upon the real world. In contrast to VR, AR does not replace the real environment; rather, it uses the real environment as a background.

The use of interactive virtual systems has been starting to be used in multiple sectors, in the professional and educational sectors, as it allows users closeness to the recreated space while allowing a rapid flow of changes and updates of the models (Xavier Calvo et al., 2018; Simpson, 2001). In the framework of urban and architecture studies, the designs must be assessed before they are built (Hisham El-Shimy et al., 2015; Kamel Boulos et al., 2017; Sidiropoulos et al., 2005). This compile educators to rethink how students learn and represent as it is important that students become skillful in multiple representation technologies, that they can incorporate the latest technologies into their design process to better communicate their proposals (Hai-Jew, 2010; Wu et al., 2010) and to facilitate the critical reasoning on the spaces they conceive (Suwa & Tversky, 1997).

2.3 Technologies between Citizens and Urbanism Students

Both, education and the cities in which we live are changing rapidly, presenting the scenery to debate future visions of transformative education and its impact on the city. To take advantage of the changes and opportunities offered by the inclusion of digital technologies, the accommodation of the digital transformation into the visualization of Urbanism is required. It is a challenge for Higher Education and society to question the *status quo* and experiment often. This sometimes means walking away from long-standing conventional processes that universities and citizens were built upon, in favor of relatively new practices that are still being defined.

The integration of digital transformation in Urbanism consists of balancing the creative act required to generate receptive environments and the social and environmental responsibilities that should be integrated into this act. It is about understanding how knowledge is produced, what the components of that knowledge are, and which are the learning processes and social practices that can be used to transmit it.

The last decades in urban design research are characterized by a focus on technological aspects of cities (Mueller et al., 2018). The concerns and interests of citizens are coming to the forefront

nowadays with the awareness that a livable city does not only consist of good infrastructure but also citizen input and feedback. The city as an objective reality and as a symbolized image plays a fundamental role in the organization of space.

However, the urban phenomenon that completes the urban structure is the result of human action and its representation as a social product (Sanchez Sepulveda, 2015). Using new technologies, for example, VR, we can work with defined urban proposals interactively rehearsing various strategies of action and collaboratively evaluate public spaces. Taking into account that the basis of the VR is to create an immersive experience and allow the user to interact with objects (Mónica Sanchez-Sepulveda, Fonseca, et al., 2019).

Given the approach of the project, it is important to take into account how the VR is a technology, that applied correctly, not only can be a useful teaching tool, but also a tool to involve society and democratize decision making in complex projects, like urban ones. Some studies show that training in a virtual environment in which 3D objects can be manipulated from any angle allows better recognition of objects than if they are taught on paper (K. H. James et al., 2002).

By incorporating VR with informal teaching models: citizens generate series of opinions or suggestions, which help students to see different points of view. In this case study, the participants are an active element of the project, and the student will have the ability to learn in real environments and projects (PBL), allowing them to obtain and improve their spatial and social skills in a very optimal way, formally and informally. This information improves their formal knowledge, as cases are conducted outside an academic environment.

The incorporation of new technologies in education should be considered as part of a global educational policy strategy. In this regard, several important aspects can be mentioned that must be taken into account (Brunner, Jose Joaquim; Tedesco, 2005):

- There is a strong social demand to incorporate the new ICTs into education, often exercised without too much information about the real value of them.
- Strategies related to new technologies require partnerships between the public sector and the private sector, as well as also alliances within the public sector itself.
- Strategies should be considered as a priority to professors. Relevant studies show that while the majority of professors show favorable attitudes towards the use of new technologies, there are cultural aspects to which are important to pay attention to.
- Given the diversity of situations and the enormous dynamism that exists in this field, political strategies should be based on the development of experiences, innovations and investigations that tend to identify the best paths for universal access to these modalities, which avoids the development of new forms of exclusion and marginality.

2.3.1 Virtual Urbanism: A User-Centered Approach

Historically, visualization and understanding of 3D space are usually achieved via physical models and drawings (X. Calvo et al., 2018). This method is changing due to a generational change and the constant improvement and development of technology. New communication media and ways of collecting data and technology that can detect social, economic and environmental patterns of the urban spaces, is supporting the discipline and creating another dimension to the practice (Mónica Sanchez-Sepulveda, Fonseca, et al., 2019).

The last decades in urban design research are distinguished by a focus on technological aspects of cities (Mueller et al., 2018). In architecture (practice and training), until recently, the use of IT (Information Technology) was restricted to project implementation processes, where various applications such as CAD and BIM served only as aids in the execution of one's work, not as tools for the decision making of the architecture and urban design project (Navarro, 2017; Sánchez-Sepúlveda et al., 2019).

Nowadays, the available solutions focus on the basic ability to develop an architectural plan, rather than maximum accuracy in representing the geometry of buildings (Xavier Calvo et al.,

2018). On the other hand, it is necessary to consider the 3D architectural rendering, particularly because new forms and systems of visualization often exceed the possibilities of traditional CAD solutions and even BIM.

Given the approach of the research, it is important to take into account how the VR is a technology, that applied correctly, taking into account that the basis of VR is to create an immersive experience and allow the user to interact with objects to operate in space (Foth et al., 2009; Horne et al., 2006; Orland et al., 2001).

The use of interactive virtual systems, in particular, has begun to be used in professional and educational sectors, as it allows users to be close to the space recreated while letting a fast flow of the changes of the model made in real-time (Xavier Calvo et al., 2018). Due to the potential of virtual systems, the spatial skills and abilities of students can work with peers and professors and participate in multi-tasking/multi-user collaborative and instant tracking (Calongne, 2008).

It is true that the new technologies that model in 3D, Virtual Reality and even videogames, correspond to progress to enhance the capacity of spatial and graphic vision and therefore ease the process of project conception (Martín-Dorta et al., 2008; Torner, 2009)**.** Gamification has been put forward as a tool to support the process of civic participation that leads to sustainable civic engagement through a process of collective reflection (Devisch et al., 2016). This tool enables citizens to observe their environment and reflect collectively on spatial issues in their daily environment. Recent approaches in the use of gamified methods for the visualization of real urban spaces to improve or generate dynamic experiments (Monica V. Sanchez-Sepulveda, Fonseca, et al., 2019):

- "Blockholm" (Stockholm, 2014), founded on Minecraft that has invited 100,000 users, technicians and experts in urban design to participate. The purpose of the game is based on designing a smart city of the future based on the real cartographic map of the city, including topography, streets, plots, rivers, lakes, etc.

- "Play the City", implemented throughout 2012 in different cities of Holland, Belgium, Turkey and South Africa and which was based on a Word of Warcraft type game.
- "SimCity" in its different versions, used as a basic system in urban planning workshops, highlighting the case of Cape Town in 2013.

All these cases were incorporated 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 conduct outside an academic environment.

They are basic proposals for zoning, for general uses at the level of an entire urbanization, or for large-scale digital work. The use of mobile devices, wearables technologies such as Virtual Reality, Augmented Reality, collaborative work, and gamified strategies are permeating our society thanks to its facility of use and effectiveness, both in training stages, as well as in professional fields (F Valls et al., 2015; Vicent et al., 2015). Using these technologies, we can work with a new way to define urban proposals interactively and collaboratively evaluating public spaces with the active participation of students, professionals and end-users.

2.3.2 New Way of Urbanism Through Digital Transformation

Cities are at the forefront of global socio-economical change, making the discipline of Urbanism an important part of the sustainable development and having an immediate effect on the challenges that society is facing. The physical, social and cultural changes that we are experimenting force the contemporary urbanist to a practice open to the processes of socially responsible participation and the conscious interaction of the culture that lives in each place. It is about constructing a scenario for urban evolution, imagining the conditions of transformation and proposing a process capable of incorporating new experiences into the human-environment relationship.

The diffusion of ICTs is having a profound effect upon the mode through which social movements and the diverse forms of active citizenship operate from below as agents of innovation, inclusion and social development (Di Bella, 2012). In the urban context, these initiatives could facilitate public decisions through the social re-evaluation of spaces, real and virtual, to respond to unsatisfied needs.

Using the implemented method, students and future urbanists should be able to incorporate informal data obtained from citizens to improve their capabilities and digital skills in the representation of information. Consequently, designs can be executed with a suitable design, adapted to space and combining the functionality, needs, and interests of citizens.

Current technology-driven implementations, while being an important step is important to understand that the main actors are the people and the human dimension of cities. The conception of a participatory innovation system in which citizens and communities interact with public authorities and knowledge developers is key. This collaborative interaction leads to co-designed user-centered innovation models of governance. The urban transformation in which citizens are the main "drivers of change" through their empowerment and motivation ensures that the major city challenges can be addressed, including sustainable behavior transformations (Thiel & Fröhlich, 2017).

To merge the main actors of the cities with the spatial forms and processes it is understood to be necessary to adapt to the new social, technological, and spatial context in which we live. Technologies, methodologies and tools for these urban processes are various. Also in the visualization aspects, the approach of Visualization and understanding of 3D, which typically accomplished via the classical view is changing due to a generational change and the continuous improvement and development of technology (Francesc Valls et al., 2017).

Present and future changes that are leading to the necessity of a faster utilization of a digital transformation strategy, can be brought by several causes like users' behavior and

expectations, new economic realities, societal changes and emerging digital technologies (https://www.i-scoop.eu/digital-transformation/, 2016). Digital transformation can renovate a sector's activities, processes, competences, and models to force the changes and opportunities of a mix of digital technologies and their accelerating impact across society in a strategic and prioritized way, with present and future changes in mind. Sectors that are involved in tackling societal challenges such as urban deterioration and unpractical city spaces, can take advantage of one or more of the existing and emerging technologies. Using technological innovation affects the mode through which social moves and the diverse forms of active citizenship operate from below as agents of innovation, inclusion and social development (Di Bella, 2012).

Combining the innovative technologies to reach citizen participation in decision-making about the construction of the city is an essential condition for urban regeneration. The act of "urbanizing" a project through digital transformation requires a vision for what parts of the process need to be transformed. In the face of the enormous amount of urban data that is needed to develop a proposal, the field of Urbanism is yet to incorporate many sources of information into their workflow.

Whether it is in the way students are trained and professionals work and collaborate, the way processes are executed, or in the way, it relates to the users, digital technology provides a meaningful opportunity. Regardless of the enormous amount of urban data to incorporate, representation technologies bring ideas into reality, allowing communication between designers, clients, contractors and collaborators (Horne, Margaret and Thompson, 2008). Professionals in the field and organizations should also commit to incorporate these technologies.

2.3.3 Social Digital Transformations

In Urbanism, there are four significant themes: (1) is for and about people; (2) the value and significance of 'place'; (3) operates in the 'real' world, with its field of opportunity constrained and bounded by economic (market) and political (regulatory) forces; and (4) the importance of

design as a process (Carmona et al., 2010). It is about constructing a scenario for urban evolution, imagining the conditions of transformation and proposing a process capable of incorporating new experiences into the human-environment relationship.

In the last decade, there have been various initiatives conducted by researchers as well as all types of organizations to explore methods and technologies to foster public participation in the design and implementation processes of social projects. One of the strategies, increasingly used, has been the implementation of these projects through new digital media. However, the use of new tools has not generated a digital transformation as was expected, among other things because of the novelty of the proposals, or even because of the use of technologies that are not commonly used by users (Thiel & Fröhlich, 2017).

This lack of success in technologically innovative proposals is due in part to the insufficiency of motivation on the part of the user, which, together with a lack of experience in the use of tools, condemns the proposals for transforming organizations into innocuous efforts. For this reason, technological innovations must be accompanied by a methodological innovation, which above all, generates greater motivation on the part of organizations and users. In this sense, it is increasingly common to find proposals that base their initial efforts on methods such as gamification, to adapt content and technologies to the needs and requirements of users.

The use of the gamification of a real space generates a virtual space and the simulation of the urban environment in which it is possible to make dynamic experiments of participation and generation of ideas, uses or changes that improve that space (D. Fonseca et al., 2017). Taking advantage of technology from the visual simulation and virtual reality, provide a delivery system for organizations to get closer to final users. Virtual reality has rapidly become one of the most exciting new computer technologies - exercising a stronghold on the popular imagination, attracting hundreds of researchers, and spawning a booming industry (Schroeder & Ralph, 1996). Working on the spatial transformation virtually is a supporting dimension of

the overall process of a structural change. We are in the need new for collaborative design processes, adapted to the new social, technological, and spatial context in which we live.

3 Empirical Work

3.1 Case Study

The empirical work of this thesis takes into account different areas of knowledge such as architecture education, visualization ICTs, gamification, citizen participation, usability, and the impact of informal feedback in formal education. The urban project we work on, promoted by the AMB (Barcelona Metropolitan Area), aims to generate spaces that are designed to meet the needs of the users. To define the space, the focus is on:

- The detection of urban problems and design of the public space defined by the municipalities involved.
- Improving the urban structure in terms of the relationship between the parties and between various functions in a limited but complex and strategic area.
- Evaluating how urban structure affects architecture and vice versa, how the understanding of the geography of new urban activities is articulated, and how free spaces and collective endowments are formalized, and their relationship with the uses and volumes of the edification.
- Providing the student with skills and competences and do it in an integrated way so that they can define the elements of the composition of the urban scenario, the technical prerequisites, as well as ask the key questions that allow understanding the opinion of the future users.

The pilot areas that are chosen at the request of the AMB and the municipalities of Santa Coloma de Gramanet and Viladecans, specifically the Eixample, Ciutat Meridiana, and El Clot-La Sagrera, to detect the social, urban and design situations of public spaces to make proposals for solving problems urban and use of public space detected there. The main intention is to generate spaces that are designed to meet what the users' wants: spacious, pleasant spaces with vegetation, dynamic uses, spaces for children's games, urban gardens, lighting, recreational and cultural activities, among others.

We created a virtual reality game in which through interactive elements, the participants shaped the urban public space. We exposed the public to use "wearables" technologies such as VR Head Mounted Display and AR in Tablets to know how virtual reality can help us to participate in a city-planning restructuring project in our city. The testing of this technology includes quantitative and qualitative techniques, with the variable of a gamified proposal and the use of visual technologies, aspects that brings innovation, and immediacy. The focus of this testing is to study the motivation, engagement, and overall experience of the participants with the technology, more than the effectiveness of the approach, as the whole urban design process hasn´t been completed, and still ongoing.

To start, we virtually recreate urban areas of the Barcelona Municipal Area assigned by three different City Halls: Barcelona City, Santa Coloma and Sant Boi de Llobregat. The virtual scenario will be an accessible environment where users can interact –play– with, to evaluate, visualize, recreate and make decisions in this space. These spaces are meant to have maximum realism, including the materials, textures, movements, and even sounds of the environment. We created a virtual reality game in which through interactive elements, the students shaped the urban public space, following previous case studies focused on similar approaches (Stauskis, 2014).

Students from the universities of the Polytechnic University of Catalonia (UPC) and La Salle - Ramon Llull University (URL) digitalize and virtualize them in a three-dimensional way. Students and professors, work on the elaboration of taking these spaces to visualize them in real-time. Students from the UPC and URL were in charge of modeling the space with different software and then analyzing the proposed methods, their profile and learning experience. They used Sketch Up or 3DMax for modeling and Unity or Unreal Engine for creating the interactive virtual environment of the space. The rendering engine allows the calculation of these features in a space to show a very dynamic and realistic result. Students were first introduced to emerging technologies such as augmented and virtual reality in a course that is focused on using

videogame technology for architecture representation (X. Calvo et al., 2018), taking advantage of improvements in real-time rendering to produce interactive content.

The idea is to assess this system with diverse users that include the students in their design process, end-users as the neighbors and professionals in the Architecture field, to visualize the scale, the textures, the relationship of the uses, the lights and shadows, etc. The participants use the glasses of virtual reality and through interactive elements, shaped the urban public space. According to their criteria and collaboratively, they could again configure the elements. Gamified Systems have tasks that have a high spatial component (rotate, move, scale, etc.) are present in video games, as well as in serious games applied to the visualization of complex models, where we can find actions in which the user must move the character in a multitude of possible combinations (Gagnon, 1985; Sedeno, 2010).

This virtual three-dimensional scenario becomes an environment that users can interact with, to recreate new spaces. Using VR Head Mounted Display, the users experimented and shaped the urban public space. The VR let users understand in an immersive way, how their actions and changes affect the environment in real-time. For example, having the capacity to be in continuous interaction with the open space while moving and rotating objects (Figure 8).

Figure 8: Examples of user's interaction with space for its modification. Two-hand joystick with different options: map to indicate your location in the site, grabbing objects to move or rotate and a catalog with urban furniture.

The virtual reality allowed participants to see in an immersive way the changes and actions that happen in the environment in real-time, for example, in the calculation of specific lighting in a

space to show a very dynamic and realistic result (Figure 9). Some participants' proposals, inserted into the simulated environment, can be in constant interaction by moving and rotating actions.

Figure 9: Lighting features of Virtual Reality.

The procedure that the participants followed was:

1. The explanation of the project was exposed and so the description of the experiment, the technology and the way they would take part in the project.
2. The way to use the tool was explained, for example, how to use the controls, how to move on the space, how to grab objects, how to move and rotate the objects, how to choose them from a catalog and how to see the cost of each object.
3. The controls and the helmet are given to the participant to start using the tool, get immersed in the virtual world and start to get familiar with the navigation system.
4. The participant is exposed to a pre-built environment, with all the existing buildings already on-site, and they get to see the catalog with all the options of objects.
5. The necessities have already been identified and participants start to interact in the space, moving to the specific place they want to propose a use and grab the objects they want, drop them in site and move and rotate them to the exact position they want.
6. When participants are choosing the objects, they get to see the price of each object.

An interesting feature of this tool is that participants get to see what they are proposing in real-time. Objects throw shadows, the participant gets to choose if the environment is seen in the

daytime or nighttime and see in real-time the lighting being put on any section of the street and how it is affected by the color, intensity or type of light being used, they get to see a real-time map while they are moving through the space to see their situation within the city and have a visible pointer that select the objects and select the options in the menu (Figure 10). This method allows the participant to see in a very immersive way the changes and actions that happen in the environment in real-time.

Figure 10: Example virtual reality scene

The purpose is to view and think about the urban transformation of public spaces and the built context, from the direct experience with the field of intervention based on virtual reality and the modeling of the project. This direct experience of space in real-time permits creating more aware and precise project decisions and warranting much more measured results. We used this system to validate the effectiveness of virtual gaming application in the urban design projects proposing to enhance the spatial perception and urban skills, due to the immersive visual technologies. Following we can detect essential elements to encourage initiatives in urban transformation and designing processes. (David Fonseca, Villagrasa, et al., 2017).

3.2 Virtualize Places

This thesis shares a gamified proposal and the use of visual ICTs, aspects that bring innovation and immediacy for the design of the urban space. This implies the participation of the main actors of this process: the designers (future architects and architects) and the end-users. This process entails the creation of a sense of community or of relevance to a specific group of users united by similar interests with the added value that the opinions or proposals do not fall in a

sack broken but rather reinforce the knowledge of students and professionals, which it is known as informal education. Informal feedback in the training of the architect is undoubtedly one of the determining factors of the project.

The success in the use of a gamified system will be closely linked to the ability to respond to the needs of users through an easy-to-use, attractive system that allows motivating the user experience and generating a satisfactory feeling of work. This methodology brings the participants as an active element of the project, able to preview the space, propose changes and be part of what later on will be a livable space.

The objective is to implement and evaluate the use of ICTs and, in particular, AR and VR in a gamified environment, given that it is a skill that complements the current competences of Architecture students and for their professional future. This aspect is in itself a teaching innovation, since gamified designs are usually made on interactive 2D/3D spaces but without virtual or augmented features. The objective is the creation of virtual urban scenarios capable of suggesting their real structure, formal and visual structures, acoustic study, textures, etc. This work on Unreal and Unity video game engines are public domain applications that allow their exploitation on all types of platforms and devices and these.

The first urban project we work on is in Sant Boi de Llobregat in a short social/urban development of Plaça de la Generalitat. Since it was built in the 70's, the square has been remodeled. Neighbors demanded intervention on the part of the Administration due to several reasons: the perception of insecurity of the neighborhood, the need to promote the trade of the surroundings and the degradation of the uses in general. The challenge is to design a new place from citizen participation to improve and transform the square according to their needs and desires (Monica V. Sanchez-Sepulveda, Fonseca, et al., 2019). To gather ideas of improvement on the square, similar to the next projects that will be described, is to 1) Informing and inviting to the participatory process; 2) Know the opinions about the state of the

current place and the proposals for improvement; 3) Carry out face-to-face surveys with neighbors; 4) Facilitation of local conferences to gather proposals for improvement. (Figure 11)

Figure 11: Plaça de la Generalitat neighbors. Collaborative design.

The second project we work on aims to create a large public space that prioritizes the people of the Eixample Esquerra District instead of the vehicles (Mónica Sanchez-Sepulveda, Fonseca, et al., 2019) (Figure 12 and 13). The site selected is part of Superilles (Super Squares) concept, where the streets are closed to the vehicle for the pedestrian and outdoor activities of the neighbors. The aspiration is to diversify the road network based on the connectivity of the streets: the basic network (connection at the city level), local network (at district level) and neighborhood network (of the origin or final destination, to get home, to trade, to work, etc.). By closing the street to vehicles and allowing it to pedestrians, the program to be situated there is design according to their criteria. Collaboratively, they stated the following conditioners:

- Address the street primarily to pedestrians
- Prevent spaces for stay and neighborhood coexistence
- Increase the low vegetation while maintaining the alignment of trees
- Increase the surface of rainwater catchment on the terrain
- Establish criteria for the location of furniture and services (garbage bins, bar terraces...)

Figure 12: Urban project first proposal.

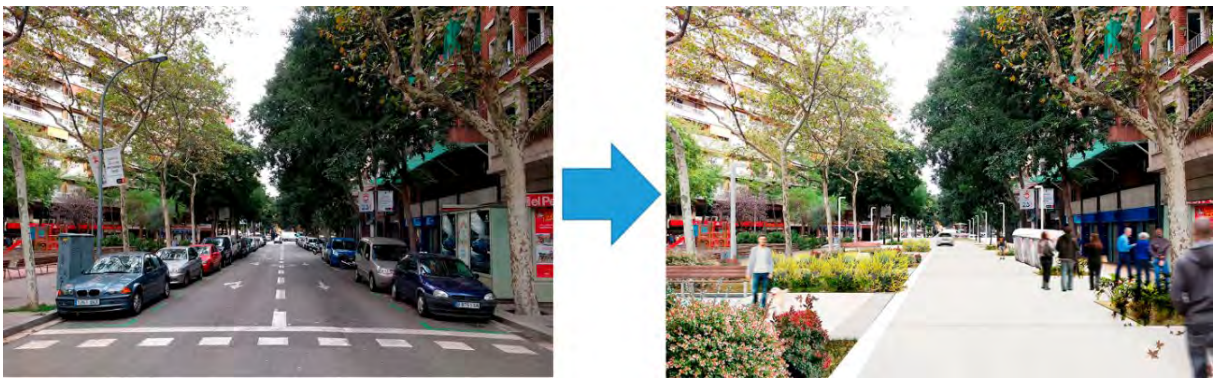

Figure 13: Comparison of the present state and future proposal.

The third project we work on is in the area of the Plaça Baró, in Santa Coloma de Gramanet. The base was to produce a collaborative design with a gender perspective from the design phase to the intervention. The aim is to create a specific space adapted to the needs of children between 6 and 12 years old. A participatory process was carried out with students of the 5th grade of the Torre Balldovina School, a neighbor of the square, as well as sessions open to the whole neighborhood. The sessions were accompanied by a process of education in architecture and urban planning with a gender perspective for children. All activities have been carried out with approaches that allow children to contribute their realities and needs related to the specific public spaces of action. Consequently, children analyze spaces with a critical eye and can propose improvements with an inclusive perspective and through collective debate and consensus.

In the first phase, neighborhood children participated, in the assignment and distribution of uses to the different parts of the square. In the second phase, the students of the Torre Balldovina School shaped the ideas generated from the different collaborative designs. Finally, the students presented their proposals to the people representing the council. For the realization of the final work, the collage technique on an axonometric was used. (Figure 14)

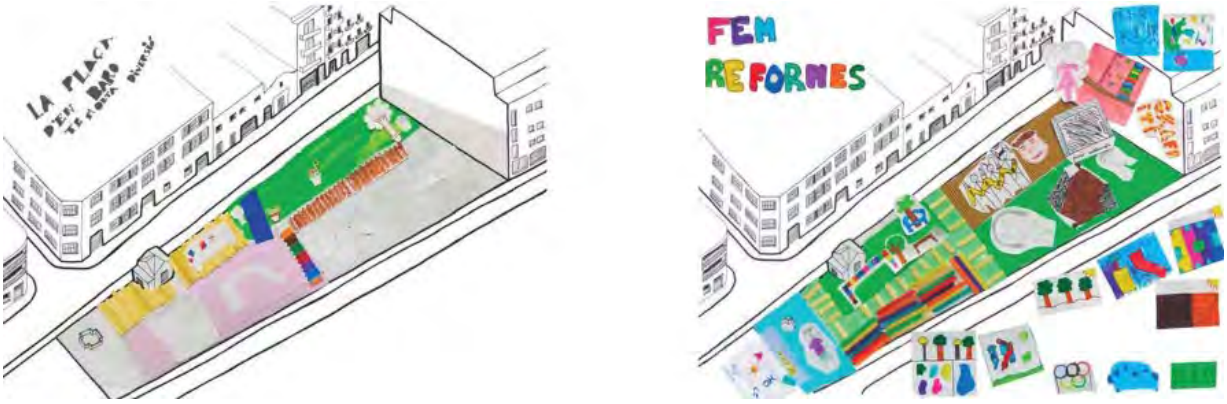

Figure 14: Work at the Torre Balldovina School.

There have also been sessions for families and careers to share their experiences and needs. The purpose is to detect problems and virtues, a bag of desires and the fabric of the networks. Taking into account that the square is a space for coexistence between different people (age, hobbies and other preferences). Sectors and uses, vegetation and reuse of the existing sources were defined, integrated with the uses and requirements of the previous phases. From this premise, the most suitable pavements for each of the zones according to their assigned use (color and texture) were chosen, and the different urban elements that could be integrated into the square were imagined and draw to decide which of them are necessary to provide service needed and guarantee the comfort of each space. (Figure 15)

Broadly speaking, the following areas of activities were defined: rest area and quiet activities (reading, drawing, rest, etc.), low-intensity motor activity zone and symbolic game (game structures, free space for games), a zone of intense motor activities (such as playing with a ball or as a team) and mediating vertical activities (cartography, chalkboard, basket, fronton...). Finally, the results were presented to the city council.

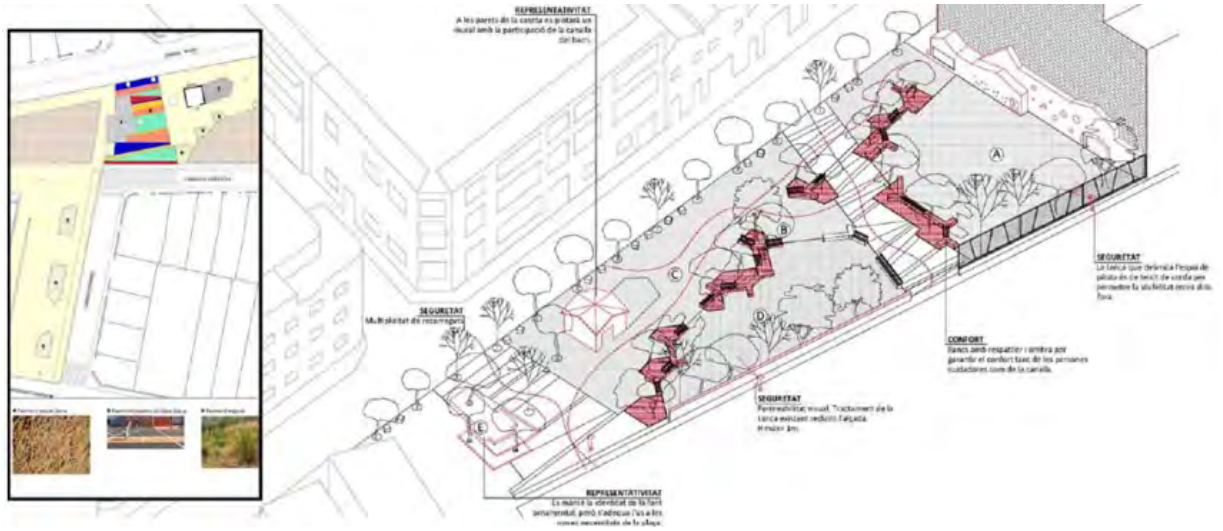

Figure 15: Uses and specifications of the proposal.

3.3 Users Tested

With the proposals generated in urban participatory processes, based on sketches and work on paper, the Architecture students passed the project to the second development phase. The main objective is to develop in the student the aptitude to value and adequately represent the visual attributes of architectural and urban elements. In this way, the concepts of the theory of form and visual perception in the representation of urban space can be applied critically. The teaching experiment has focused on evaluating the resolution of the visual simulation of the urban scene as a whole, including all the elements of urban furniture, trees, day and night settings, in a conventional way, using classic render engines or navigating within the model using real-time render engines and VR for the inspection of it and its subsequent adjustment.

At this point, it is important to analyze the profile of students, especially to analyze their subsequent responses to the utility and uses of virtual interactive systems, especially to reveal whether or not they are prepared for a change of paradigm. This meaning, the migration of traditional systems of representation (plans and models), to new interactive and multiplatform 3D systems.

The idea is that with the virtualize scenarios, the students, end-users (neighbors), and professionals in the Architecture field can use this system to visualize the scale, the textures, the relationship of the uses, the lights and shadows, etc. and contribute in the design process. The objective is to bring all the actors of the design process the technology of virtual reality so that they can participate in the definition of the uses of the public spaces in the most realistic way before its development.

With students we design an educational activity based on a PBL method to evaluate student behavior, motivation and adaptation to pedagogical innovations that involve the use of different work technologies and visualization of complex 3D models, an approach with excellent previous results (Campanyà et al., 2019; Pons et al., 2019; Suwono & Dewi, 2019). The perspective of PBL is easily adapted to the training of Architecture students, who work with real exercises and initiatives from the very beginning of their coursework (M. V. Sanchez-Sepulveda, Torres-Kompen, et al., 2019).

We work with two groups of students. In the first group, the students were selected from a 4th year subject at the Superior Technical School of Architecture of Barcelona, Polytechnic University of Catalonia. They used Sketch Up for modeling and Unity for creating the interactive virtual environment of the space. The second group has students from a 2nd year subject at the Superior Technical School of Architecture of La Salle, Ramon Llull University (Figure 16), where the students used 3DMax and Unreal reproduced the same spatial area that the first group.

The course is focused on using videogame technology for urban design representation (X. Calvo et al., 2018), taking advantage of improvements in real-time rendering to produce interactive content. The students participated in an educational experience that sits at the intersection of architectural representation and urban design.

Figure 16: Examples of two students' proposals for their assigned section in Plaça Baró.

The active design feedback from the city's inhabitants is an essential way towards a responsive city. We, therefore, propose a system to merge citizen feedback, which requires a structured evaluation process by the students to integrate for urban design and transmit it to stakeholders and public agencies. (Figure 17).

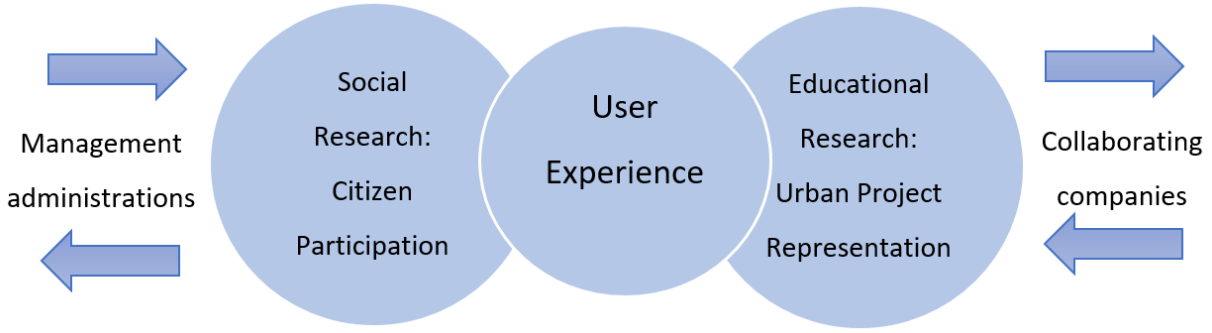

Figure 17: Management processes of the urban project

In this regard, the first question to be resolved is: What is the purpose of citizen participation? The objects of citizen participation focus on:

- Encourage the participation of territorial agents and citizens in general in the proposals for changing the urban environment where they live.
- Obtain absolute transparency of the process and the involvement of stakeholders.

- Obtain the valuable information provided by citizens, making them partakers of decisions about the surrounding environment.

The objective is how to satisfactorily involve the citizen in these assessment processes. Starting from previous studies carried out in professional and teaching environments where gamified strategies and the use of ICTs focused on enhancing augmented and virtual visualization entails an increase in user motivation and an improvement in their skills, a gamified system of interactive collaboration to obtain the citizen response.

Figure 18: Fair Research in Direct 2018. Multimedia gallery. https://recercaensocietat.wordpress.com/galeria-multimedia/. Accessed May 7, 2018.

To make the test with the citizens/end-users we participated in the Research Fair in Direct in Museum Cosmo-Caixa (Figure 18) in Barcelona, presenting and exhibiting the project. We exposed to the public to use "wearables" technologies -VR Head Mounted Display- to know how virtual reality can help us to participate in a city-planning restructuring project in their city, after having gone through the interactive virtual experience. This approach is similar to what has been done in previous experiments in the architecture educational framework (David Fonseca, Isidro Navarro, Sergi Villagrasa, Ernest Redondo, 2017; D. Fonseca et al., 2017).

To get feedback from the professionals in the Architecture field we participated in Construmat: International Construction Fair (Figure 19). To analyze and evaluate the advantages and

disadvantages of virtual systems in the process of developing the urban and architecture project on their experience of using virtual systems during the design of urban environments. There were defined challenges to be solved by users and that generate complementary information before the generation of the project, knowing the type of participants, their opinions modifying the scenario and it can be interpreted as the support or rejection of a proposal.

Figure 19: Participation of professionals in the Construmat International Construction Fair.

3.4 Evaluation Criteria

To validate that the virtual gaming application for the development of urban design projects, we have identified four main evaluation criteria that will help in detecting the essential elements helping promote initiatives in both urban transformation and designing processes (David Fonseca, Villagrasa, et al., 2017):

- Assess the incorporation of immersive ICTs and gamification in the educational process (specifically in the urban project).
- Assess the motivation and usability of the gamification platform by the users.
- Study and establish links between the profiles of the users and the results of the surveys.
- Determine the relationship between satisfaction, motivation and user experience.

It was used the mixed evaluation method (using quantitative and qualitative data), which allows us to identify positive and negative aspects more objectively. In the experimentation research of working hypotheses based on participants' responses, a basic issue is the correct design of methods that allow data extraction. The behavior of the user with a new system provides information crucial for the success of its final implementation.

Some examples of quantitative methods used in scientific research are profile tests, satisfaction surveys and usability tests. If it is possible to work with big enough samples (of minimum 30–50), quantitative information can be collected, and the results can be analyzed and compared to find statistical differences (P. Delamont & Atkinson, 2010). With fewer users (less than 10), however, the qualitative approach has proven to be equally valid with the ability to obtain a detailed explanation of the variables of the study (S. Delamont & Atkinson, 2010). Using a hybrid approach, we used the mixed-methods research approach to achieve complementary results.

There are quantitative methods, like profile tests, satisfaction surveys and usability tests. The classic tool in this context is the survey, which is often designed to measure the response concerning the usability of a system, his/her perception in general and the degree of satisfaction with the proposed method. To analyze the proposed methods, we used a system for data extraction that was earlier proven in other educational studies in the same field (David Fonseca et al., 2016; David Fonseca, Redondo, et al., 2017).

Students

To evaluate the profile of the students an initial pre-test was created to get the student's level of familiarity/motivation about the use of selected technologies. This test is given at beginning of the course and the students are asked to estimate their degree of knowledge, use, and interest in technologies and specifically in the use of informatics devices and mobile technology, the Internet, and serious games. The objective of this initial survey is to evaluate the extent of their similarities to validate the differentiation of the experiment and its results.

At the end of the course, a post-test was created to evaluate the level of usability of the technologies used and their possible relation and uses with their studies and future projects. The core of this test is to assess the students' perception of the utility of the systems executed and use in their studies, future deliveries and professional undertakings. The objective is to evaluate students' satisfaction when completing the experience at the end of the course. The structure of the post-test is based on the International Organization of Standardization (ISO) 9241-11 and make achievable to assess the usability of the VR technology and interactive-gamified methods in educational environments.

The students were also asked about their main perceptions (P1 to P7), including their valuation of the proposed methodology, perceived usefulness, and level of satisfaction. In addition, we incorporated their assessment of the gamification processes (G1 to G3).

Perception indicators

- P1 – Digital 3D visualization of Architecture/Urban projects is very important to understand the space.
- P2 – The use of Virtual Reality to display A/U projects is useful for their understanding.
- P3 – Based on the proposal used, I am motivated to use VR in my future projects for their presentation and understanding.
- P4 – Models scale is suitable to manipulate virtual elements.
- P5 – The materials, textures and lighting of a virtual environment must always be the

most realistic possible.

- P6 – The existence of background music is better and satisfies the user in the interaction with virtual spaces.
- P7 – The visualization device has a considerable influence on virtual quality perception.

Gamification indicators

- G1 – The use of gamified environments (with missions and achievements) are better than simple free navigation in a virtual space.
- G2 – Playing games, I prefer one-to-one games vs. multiplayer environments.
- G3 – I consider that using games in educational environments can help to understand better the typology and correction of the materials used in the scenes.

Students and Citizens

To evaluate the feedback of the citizens (end-users) and to compare it with the students, we delivered the participants questionnaires after using the virtual proposals (which is based on previous experiments done in architecture educational framework, (David Fonseca, Isidro Navarro, Sergi Villagrasa, Ernest Redondo, 2017; D. Fonseca et al., 2017)). To both groups, we design a Likert scale where participants evaluate from 1 to 5 their level of agreement with 13 statements exposed about different aspects.

Following our assumption, we have analyzed the Intrinsic Motivation (using the Intrinsic Motivation Inventory [IMI], previously validated and used in similar works (Mónica Sanchez-Sepulveda, Fonseca, et al., 2019) of the students with the function of the following seven indicators:

- IMI-1: I enjoy playing and using virtual environments. I think this kind of experience is very amusing and entertaining.

- IMI-2: Using 3D viewing, I can acquire better architecture skills related to the 3D space in front of the traditional systems (print sheets, posters, etc.).
- IMI-3: I believe that the use of virtual and gamified proposals needs less effort than traditional systems.
- IMI-4: The use of interactive-virtual proposals generates less stress that systems based on panels and mock-ups.
- IMI-5: I think that using virtual proposals I can change the future way of working, understanding, and showing the architectural and urban projects.
- IMI-6: Serious games and virtual interactions and navigation are systems useful for my future and can benefit me.
- IMI-7: Interactive and gamified systems help me in collaboration with other users/partners/friends/colleagues, expanding my social relations.

Additionally, and to compare potential differences in behavior/perception according to the user profile and the level of the students, the students were asked based on the following criteria:

- Soc-Urb1: These systems facilitate decision making in urban projects.
- Soc-Urb2: The interactive virtual systems allow the design and re-evaluation of urban spaces.
- Soc-Urb3: They allow identifying possible unsatisfied social needs.
- Dig-Sk1: With the information obtained from the users, the students can incorporate the data to optimally modify their projects and proposals.
- Dig-Sk2: The opinion of the final users helps and should serve to improve the training/competencies of the student.
- Dig-Sk3: These systems help to improve digital skills in complex representations of students.

Surveys were seeking to complement, compare and analyze the data previously studied in previous phases of the Project (Mónica Sanchez-Sepulveda, Fonseca, et al., 2019), to establish

the training needs of students according to the level of the subject, and of the available technologies at the educational level. Based on the results obtained through the completed quantitative surveys, and in line with previous studies with mixed approaches, we completed a series of Bipolar Laddering interviews (Pifarré & Tomico, 2007), to specifically identify relevant aspects, both positive and negative, of the experience that can explain the results obtained in the quantitative phase (David Fonseca et al., 2015, 2016). The BLA method works on positive and negative poles to define the strengths and weaknesses of a product. Conducting a BLA consists of three steps: Induction of the elements, marking of elements, and element definition. The questions "Why is it a positive/negative element?" and "Why this score?" are asked. The answer must include a specific explanation of the exact characteristics that make the mentioned element a strength or weakness of the product. In this type of analysis, the Positive/Negative Common (PC/NC) elements are the most representative because they are the most cited. Depending on the reference rate and its average obtained value, we can identify the most relevant elements.

Students and Professionals

To evaluate the feedback of the students and professionals regarding the competences reinforced, we tested both groups on the same projects using VR (Figure 20).

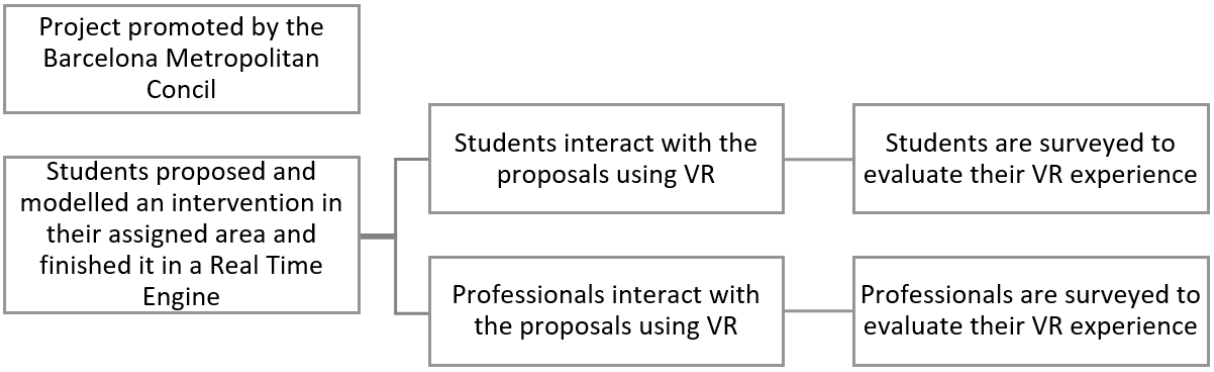

Figure 20: Scheme of the process.

Afterward, we used a Likert scale for the design of the survey for users to evaluate each statement from 1 to 5 based on their level of agreement. The survey has 10 statements about

different aspects related to the effectiveness of virtual systems on the design of urban environments. The statements are based on the competences in the curriculum for urbanism of the School of Architecture (Table 1).

Survey statements: The interactive VR system helps…

1. Easily identify the needs and requirements of the human scale.
2. Understand the relationship between people and the natural or artificial environment and objects.
3. Critically evaluate the result of urban design and make decisions.
4. Transmit ideas, problems and solutions to a specialized and non-specialized public.
5. Apply formal, functional and technical basic principles to the conception and design of urban complexes.
6. Understand the relationship between buildings and the spaces between them.
7. Analyze local conditions, establish dimensions and relationships of urban spaces.

Knowing the interactive VR system…

8. It would motivate me to change my way of working in the future.
9. I would use this system to defend the arguments of urban projects.
10. I would use this system to defend the arguments of architectural projects.

The base to make the survey and assess the effectiveness of the virtual systems in the processes of urban design are the Urbanism Competences (Figure 21) that are required in the training of Urbanism in Spain, based on the White Book (*Libro Blanco*), that aim of carrying out studies and useful practical cases in the design of a degree adapted to the European Higher Education Area (EHEA).

Survey Statement #	Urbanism Competence
1, 2 y 6	Ability to comprehend the relations among people and buildings, between buildings and their surroundings, and buildings and spaces among them based on human scale and needs
3	Capable of making decisions (in projects, construction systems, organization, etc.)
4	Capability to communicate ideas, information, problems and solutions to a specialized and non-specialized public
3	Capable of acquiring the self-critical capacity
5	Aptitude or ability to apply the basic formal, functional and technical principles to the conception and design of buildings and urban complexes
7	Aptitude or ability to develop building programs, considering the requirements of customers and users, analyzing precedents and location conditions, applying standards and establishing dimensions and relationships of spaces and equipment
2	Understanding the relationships between human behavior, the natural or artificial environment and objects, according to human requirements and scale

Figure 21: Competences in the curriculum for Urbanism of the School of Architecture, La Salle – URL that relates to each Survey Statement.

4 Articles by Compendium

This thesis has been developed from three lines under the theoretical and empirical work, exposed in the previous chapters, that links with the defined working hypotheses and with the articles that make up the compendium:

- ✓ Line 1. Analyze the concept of Urbanism as a discipline from the training to the practice and examine the use of ICTs in the training of courses related to urban design. Prepare surveys to study the profile of the students (technological and social aspects), as well as the degree of motivation in the use of technologies and their future applications. (H1 and H2)
  - Related to LINE 1, the ARTICLE A is presented:

    Evaluation of interactive educational system in urban knowledge acquisition and representation based on the students' profile. Monica Sanchez-Sepulveda, David Fonseca, Alicia Garcia-Holgado, Francisco Jose Garcia-Peñalvo, Jordi Franquesa, Ernesto Redondo, Fernando Moreira. Expert Systems 2019. Ed. Jon G. Hall. ISSN: 0266-4720 eISSN: 1468-0394. WILEY 111 RIVER ST, HOBOKEN 07030-5774, NU, ENGLAND. Accepted date: April 6, 2020, Published: May 2, 2020. DOI: 10.1111/exsy.12570
    - 2018 Journal Impact factor: 1.505. Journal Citation Reports Ranking: **Q2** in Computer Science, Theory & Methods 2018
    - The AUTHOR'S CONCRETE CONTRIBUTION in this article has focused in the compilation of the action framework, conceptualization, methodology, investigation, writing (original draft preparation, review and editing), visualization, validation and conclusions.

- ✓ Line 2: Test the usefulness of digital tools in the management of urban projects related to the urban designer required competences. Evaluate the relationship of methodologies such as ICTs and gamification to the general and specific phases of the urban design, through professionals and students in the Architecture field. Determine the correlation between motivation, satisfaction and experience of use, and the improvement of space. (H1)

- Related to LINE 2 ARTICLE B is presented:

  Methodologies of Learning Served by Virtual Reality: Case Study in Urban Interventions. Mónica Vanesa Sánchez-Sepúlveda; Ricardo Torres Kompen; David Fonseca Escudero; Jordi Franquesa-Sánchez. Applied Sciences-Basel (CODEN: ASPCC7) ISSN: 2076-3417 eISSN: 2076-3417. MDPI ST ALBAN-ANLAGE 66, CH-4052 BASEL, SWITZERLAND. Accepted: November 25, 2019; Published: November 28, 2019. Vol. 9 (23), 5161. DOI:10.3390/app9235161

  - 2018 Journal Impact factor: 2.217. Journal Citation Reports Ranking: **Q2** in Physics, Applied 2018.
  - The AUTHOR'S SPECIFIC CONTRIBUTION in this article has focused in the compilation of the theoretical framework, conceptualization, designing the survey, methodology, investigation, writing (original draft preparation, review and editing) visualization, collecting and computing the data of the survey, make the comparative analysis of the results, validation and the conclusions.

✓ Line 3: Evaluate the usability, motivation and satisfaction of the serious games applied to the field of teaching of the urban project, citizen participation and involvement in the simulation of processes for decision-making and design. The profile of the end-users and students will be evaluated, their motivation in the use of ICTs and finally their degree of satisfaction with the gamified systems used. (H2)

- Related to LINE 3, the ARTICLE C is presented:

  Virtual interactive innovations applied for digital urban transformations. Mixed approach. Mónica Sanchez-Sepulveda, David Fonseca, Jordi Franquesa, Ernesto Redondo. Future Generation Computer Systems. ISSN: 0167-739X ELSEVIER SCIENCE BV. PO BOX 211, 1000 AE AMSTERDAM, NETHERLANDS. Accepted date: August 7, 2018, On-line: September 9, 2018, Vol. 91 - February 2019, pp. 371-381. DOI: 10.1016/j.future.2018.08.016

- 2018 Journal Impact factor: 5.768. Journal Citation Reports Ranking: **Q1** in Computer Science, Theory & Methods 2018
- The AUTHOR'S SPECIFIC CONTRIBUTION in this article has focused in the compilation of the theoretical framework, conceptualization, methodology, validation, investigation, writing (original draft preparation, review and editing), visualization, collecting and computing the data of the survey, the study of the relationships between the results and conclusions.

4.1 Order of the Articles

- Article A: Pages (17 pages): 107 - 124
- Article B: Pages (12 pages): 125 - 137
- Article C: Pages (10 pages): 139 – 149

Evaluation of interactive educational system in urban knowledge acquisition and representation based on the students' profile.

Monica Sanchez-Sepulveda, David Fonseca, Alicia Garcia-Holgado, Francisco Jose Garcia-Peñalvo, Jordi Franquesa, Ernesto Redondo, Fernando Moreira.

Expert Systems 2019. Ed. Jon G. Hall. ISSN: 0266-4720 eISSN: 1468-0394. WILEY 111 RIVER ST, HOBOKEN 07030-5774, NU, ENGLAND.

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applied sciences

MDPI

Article

Methodologies of Learning Served by Virtual Reality: A Case Study in Urban Interventions

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Featured Application: Methods for educational purposes, such as courses related to Urban Design in Architecture Schools.

Abstract: A computer-simulated reality and the human-machine interactions facilitated by computer technology and wearable computers may be used as an educational methodology that transforms the way students deal with information. This turns the learning process into a more participative and active process, which fits both the practical part of subjects and the learner's profile, as students nowadays are more technology-savvy and familiar with current technological advances. This methodology is being used in architectural and urbanism degrees to support the design process and to help students visualize design alternatives in the context of existing environments. This paper proposes the use of virtual reality (VR) as a resource in the teaching of courses that focus on the design of urban spaces. A group of users—composed of architecture students and professionals related to the architecture field—participated in an immersing VR experience and had the opportunity to interact with the space that was being redesigned. Later, a quantitative tool was used in order to evaluate the effectiveness of virtual systems in the design of urban environments. The survey was designed using as a reference the competences required in the urbanism courses; this allowed the authors to identify positive and negative aspects in an objective way. The results prove that VR helps to expand digital abilities in complex representation and helps users in the evaluation and decision-making processes involved in the design of urban spaces.

Keywords: information and communication technologies; higher education; urban design; virtual reality; learning methodologies; architecture schools; teaching/learning strategies; interactive learning environments

1. Introduction

Any research in the educational field should start by considering how students learn. Ambrose [1] states that learning is a process and not a product, but since this process takes place in the mind, it can only be assumed that it has taken place by analyzing changes in the learners. Whenever a professor designs a class, the first issue that must be considered is the audience. The nature of students—their academic preparation, aspirations, and cognitive development—affects the professor's elections on what and how to teach. The focus should not be on the teaching of the specific contents of the subject (such as physics, Spanish, mathematics, art, and so on), but on the students as an audience [2]; this requires an understanding of how the human mind learns. There are certain kinds of delivery that are

more effective in terms of communication than others, meaning that they make it easier for people to pay attention, remember and grasp concepts, and process information and knowledge [2].

Centuries of teaching at University level have been characterized by an audience of students taking notes from a professor delivering authoritative lectures, to later test students on their knowledge and assign grades [3]. However, over the past thirty years, research on theories of learning and cognitive development and students' academic success has confirmed that teaching that emphasizes active learning and collaborative activities, and that promotes intellectual engagement on students, is more efficient. Professors interact with students in ways that allow the latter to obtain new information, practice new competences, and rethink and expand on what they already know. Other relevant concepts and ideas provided by previous studies [2], that will also be taken into account in this study, focus on several characteristics of human beings. According to these studies, they are as follows:

- Are innate learners, capable of remembering and absorbing uncountable details about objects and other people [4,5]?
- People Learn by connecting new information to what they already know [4,6].
- People learn what they consider relevant to their lives [7].
- People learn informally by building knowledge in social groups [8], but also learn individually and in one-on-one situations [5].
- People learn when they are motivated to do so by receiving encouragement from other people in their lives [9].
- People do not learn satisfactorily when their main learning environment is professor-centered, and it requires passively listening while the professor talks. Human beings cannot pay attention for long when their brain is in an inactive state [5,7,10–14].
- People learn more when they obtain new material several times by using diverse methods, which require the use of different parts of their brain [15–17].
- People learn when they actively examine their learning and performance [4].
- People learn less by going through the material and more from being examined by others or themselves on it, as it implicates more cognitive processing and requires them to practice retrieving information [18–20].
- People learn more when the material helps stimulate emotions and not just intellectual or physical involvement [21–23].

For most people, part of the value of a career in academia is the chance to help learners in their path to becoming future professionals in the field, and share their enthusiasm with others; for this reason, it can be discouraging for them to look into a classroom and see disengaged students. This lack of engagement and motivation happens mostly when it is hard for the learners to connect what they are learning to existing knowledge; when they are learning passively and individually; when the information is explained just one time or in only one way, making it more difficult to understand its relevance; and when the material does not evoke emotions and does not produce an action-reaction experience. For students to understand the concepts being presented to them, it is crucial that they are engaged. The more the student is engaged in academic work, the greater the level of knowledge achievement and general cognitive expansion.

Information and communications technologies (ICTs) have transformed our society and, by extension, education [24]. The methods in which we communicate have been continuously adjusting to include characteristics such as interconnection, interaction and mobility. Several studies [25] show the opportunities offered by these emergent technologies, as they allow for a new type of reality where physical and digital environments, media and interactions are intermingled through our everyday lives. The use of interactive virtual systems, in particular, has begun to be used in professional and educational sectors, as it allows users to be close to the space recreated while letting a fast flow of the changes of the model made in real time [26].

Recent studies [27] focus on the adaptation of contents and their application using ICTs in the fields of architecture and urban design, focusing on the student, and their satisfaction and motivation. From an academic perspective, ICTs enhance the acquisition of spatial competences to study the visual impact of urban or architectural projects. Particularly, in architecture and urban design courses, it is necessary to evaluate whether a design is appropriate before being built, leading educators to reconsider how students represent the designs and learn to make this evaluation. Thus, it is important that students develop skills in various representation technologies, and can integrate the latest technologies in their design process, with the aim of better communicating their proposals, and to facilitate analytical thought on the spaces they design [28].

Throughout the history of architecture education, understanding and visualizing 3D spaces has been usually done by means of drawings and physical models instead of 3D models and virtual visualizations [29]. The use of these new methods is emerging because of generational change and the continuous development and improvement of technology [30]. New technologies are transforming the way these processes are carried out. The world that surrounds us is now becoming progressively digital, in particular for newer generations that are technologically savvy and familiar with the use of mobile devices and cloud computing services [31], and the integration of this new approach and paradigm in the specific context of the education and professional practice of urbanism is crucial.

In education, mixed reality (MR) is a new approach that transforms the way students deal with information. MR technologies, namely virtual reality (VR) and augmented reality (AR), are used in architectural and urbanism research and practice to support the design process, to visualize design alternatives set in existing built environments, and to assess people's reaction to their living environment.

Virtual reality (VR) is a combination of technologies used to visualize and provide interaction with a virtual environment. The variety of settings in which VR could be used to represent make it largely relevant to many areas in education. An important characteristic of VR is that it allows for multi-sensory interaction with the space being visualized. The combination of multi-sensory interactivity makes VR ideally suitable for efficient learning, as it benefits from the advantages provided by active learning through experiences, which is the main reason why we choose this system for this case study [32]. Virtual reality is broadly used in the industry and is starting to be more affordable for users. AR and VR share features like interaction, navigation and immersion [33]; AR may be defined as a VR variation in which the user can see virtual objects mixed or superimposed upon the real world. In contrast to VR, AR does not replace the real environment; rather, it uses the real environment as a background.

One of the main motivations of university students is to be well prepared for their professional life and so they expect more courses to involve practical applications during their academic studies. Visual communication skills are connected to the competences required for professional practice. Architects should be able to choose a suitable representation medium, such as traditional graphics and digital technology tools, in order to communicate fundamental formal elements during each phase of the programming and design process.

2. Methods and Technologies

This case focuses on the subject Computer Tools II at the La Salle Architecture School (Ramon Llull University) during the academic year 2018–2019; in this course, students are introduced to emerging technologies such as augmented and virtual reality. The course is focused on using videogame technology for architecture representation [34], taking advantage of improvements in real-time rendering to produce interactive content. The students participated in an educational experience that sits at the intersection of architectural representation and urban design. The case study proposed to the students was part of an urban project promoted by the Barcelona Metropolitan Council, which aims to generate spaces that are designed to meet the needs of users. It takes into consideration that are spaces pleasant with vegetation, have dynamic uses, spaces for children's games, urban gardens, lighting, recreational and cultural activities, among others [35].

The case consisted in the re-urbanization of the area of Plaça (square) Baró, in Santa Coloma de Gramanet, Barcelona, according to the needs of the neighbors, which had been previously detected [35]. The course was split in two parts: first, the students were divided into groups of two students, and each group was assigned to work on a part of the urban environment of the square. During the following weeks, the groups modeled and textured the proposals of their respective sections, following simple guidelines regarding aspects such as maximum building size. At the end of this process, all the models were consolidated into a single environment, shared by all groups (Figure 1).

Figure 1. Examples of two students' proposals for their assigned section in Plaça Baró. One is a playground for children and the second one is a skate park for the youth.

The students work on these spaces to visualize them in real time, using Unreal Engine. The idea is that now neighbors and the city council are able to visualize the scale, the textures, the lights and shadows, amongst other elements, in the context of the needs and uses of citizens. Virtual reality allowed participants to see in an immersive way the changes and actions that happen in the environment in real time. For example, in the design of specific lighting—to be able to see the change from daylight to nightlight in a space, in a dynamic and realistic way. This powerful rendering engine allows for the calculation of lighting, and the user can (from a first-person perspective) design the lighting of an urban environment, try it on any section of the street and see how it is affected by the color, intensity or type of light being used [34] (Figure 2).

Figure 2. Dynamic view of night and day light. Work made by the students of La Salle—Ramon Llull University (URL).

This virtual three-dimensional scenario becomes an environment that users can interact with, in order to recreate new spaces. These spaces are meant to show maximum realism, including materials, textures, movements, and even sounds of the environment. Using VR glasses, the users experimented and shaped the urban public space. The VR let users understand in an immersive way how their actions and changes affect the environment in real-time (Figure 3). For example, having the capacity to be in continuous interaction with the open space while moving and rotating objects.

Figure 3. Examples of user's interaction with space and its effects. Two-hand joystick with different options: map to indicate your location in the site, grabbing objects to move or rotate and a catalog with urban furniture.

To validate that the virtual gaming application in the teaching of urban design projects enhances the spatial perception and urban competences, thanks to the immersive visual technologies, we have identified four main objectives that will help in detecting the essential elements that may help promote initiatives in both urban transformation and designing processes [36]:

- Assess the incorporation of immersive ICTs and gamification in the educational process (specifically in the urban project).
- Assess the motivation and usability of the gamification platform by the users.
- Study and establish links between the profiles of the users and the results of the surveys.
- Determine the relationship between satisfaction, motivation and user experience.

In architecture schools, urban design implies a dialogue between buildings aesthetics, scales and strategy, making possible the construction of the land and the city as a whole. This requires the architect to have a training in urbanism [37]. The competences (Table 1) required in urbanism courses in Spain are based on the White Book (Libro Blanco) that contains the design principles of studies and practical cases to be used in the design of a degree adapted to the European Higher Education Area (EHEA). These competences may be used as starting points for the creation of the survey and the assessment of the effectiveness of virtual systems in urbanism.

Table 1. Competences in the curriculum for urbanism of the School of Architecture, La Salle—URL that relates to each survey statement.

Survey Statement #	Urbanism Competence
1, 2 y 6	Ability to comprehend the relations among people and buildings, between buildings and their surroundings, and buildings and spaces among them based on human scale and needs
3	Capability of making decisions (in projects, construction systems, organization, etc.)
4	Capability to communicate ideas, information, problems and solutions to a specialized and non-specialized public
3	Capability of acquiring self-critical capacity
5	Aptitude or ability to apply the basic formal, functional and technical principles to the conception and design of buildings and urban complexes, defining their general characteristics and benefits to be achieved
7	Aptitude or ability to develop building programs, considering the requirements of customers and users, analyzing precedents and location conditions, applying standards and establishing dimensions and relationships of spaces and equipment
2	Understanding the relationships between human behavior, the natural or artificial environment and objects, according to human requirements and scale

To analyze and evaluate the advantages and disadvantages of virtual systems in the process of developing an urban and architecture project we surveyed architecture students of La Salle—Ramon

Llull University (URL) and professionals in the construction field at Construmat International Construction Fair, on their experience of using virtual systems during the design of urban environments. We asked users to wear VR glasses to evaluate how this method can help in designing urban spaces in our city, Barcelona (Figure 4) after having gone through the interactive virtual experience; this approach is similar to what has been done in previous experiments in the architecture educational framework [38,39].

Figure 4. Participation of professionals in the Construmat International Construction Fair.

Some examples of quantitative methods used in scientific research are profile tests, satisfaction surveys and usability tests; if it is possible to work with big enough samples (of minimum 30–50 points), quantitative information can be collected, and the results can be analyzed and compared with the purpose of finding statistical differences [40]. The classic tool applied in similar scenarios is the survey, which is usually aimed at quantifying the effectiveness of a system, the users' opinion in general, and their level of satisfaction with the proposed method. The value of research lays not so much on the epistemology of the method, but on its efficiency [41], as quantitative methods are considered objective [42,43] and require deduction to interpret results (Figure 5).

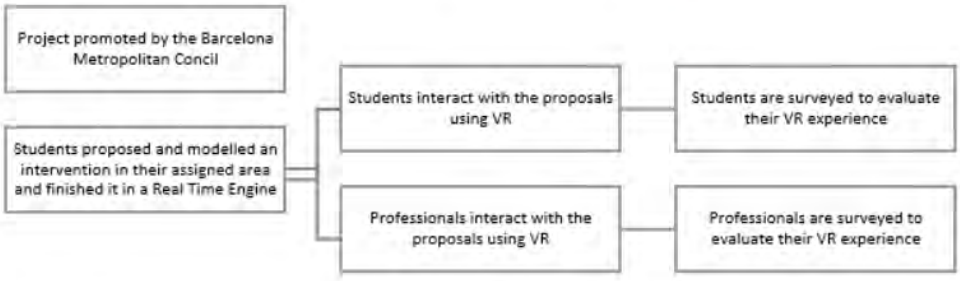

Figure 5. Scheme of the process.

We divided the group of users in two. The first group (professionals) was composed of 28 women between 20 and 57 years old (age average, AA: 31.89 and standard deviation, SD: 14.31) and 51 men (AA: 33.86, SD: 14.31, between 20 and 68 years old). In the second group, (architecture students), there were 17 women (AA: 20.76, SD: 1.56, between 19 and 24 years old) and 14 men (AA: 21.14, SD: 2.77, between 19 and 25 years old). We used a Likert scale for the design of the survey for users to evaluate the statement from 1 to 5 based on their level of agreement. The survey has 10 statements about different aspects related to the effectiveness of virtual systems on the design of urban environments

(Table 2). The statements are based on the competences in the curriculum for urbanism of the School of Architecture in Table 1.

Table 2. Survey with ten statements about different aspects related to the effectiveness of virtual systems on the design of urban environments, using the Likert scale.

		Disagree -> Agree				
The interactive virtual reality (VR) system helps:		1	2	3	4	5
1.	Easily identify the needs and requirements of the human scale					
2.	Understand the relationship between people and the natural or artificial environment and objects					
3.	Critically evaluate the result of an urban design and make decisions					
4.	Transmit problems, solutions and ideas, to a non-specialized and specialized public					
5.	Apply formal, functional and technical basic principles to the conception and design of urban complexes					
6.	Understand the relationship between buildings and the spaces between them					
7.	Analyze location conditions, establish dimensions and relationships of urban spaces					
Knowing the interactive VR system:		1	2	3	4	5
8.	It would motivate me to change my way of working in the future					
9.	I would use it to defend the arguments of urban projects					
10.	I would use it to defend the arguments of architectural projects					

3. Results

We analyzed the value given to each of the statements described on the Table 2 and decided to compare the users based on their background (professionals and students) and within each group, by gender (female and male) to see if there are any differences, as previous work [44] has proved that there is a significant difference between these factors. In the present study, we only chose users that were related to the architectural field. Separating professionals from students, we then separated them by gender. In both groups (male and female) of the professional group, statement #5 obtained the lowest value in both groups, while statements #8 and #3 shared the next lowest value (Figure 6). However, the highest values were different. Male users valued statements #4, #6 and #1 as the highest (in that order), and female users valued statements #9, #4 and #2 as the highest (in that order), having statement number #4 in common.

Figure 6. Answers of males and females in the professionals' group.

To estimate the probability that profiles by group are significantly similar, we used the Student's *t*-test (Gosset, 1908), using a null hypothesis (H_0) that stated that there were no differences in scores between groups. Statistical significance (two-tailed) obtained was $p = 0.2812$, which exceeded the threshold of 0.05, which meant a low probability that the responses based on gender for the professional users were different.

Comparing both groups there were no significant differences. It was barely noticeable that 80% of the statements obtained a higher valuation from the male group, where statements #2 and #3 are the exceptions, were more valued by women (Figure 7). The lowest values were found in the statement #5 with a global average of 4.10 (SD: 0.79) followed by #8 with an average of 4.19 (SD: 0.78), while at the opposite end with averages of 4.51 (SD: 0.66) and 4.49 (SD: 0.77), we found statements #9 and #4).

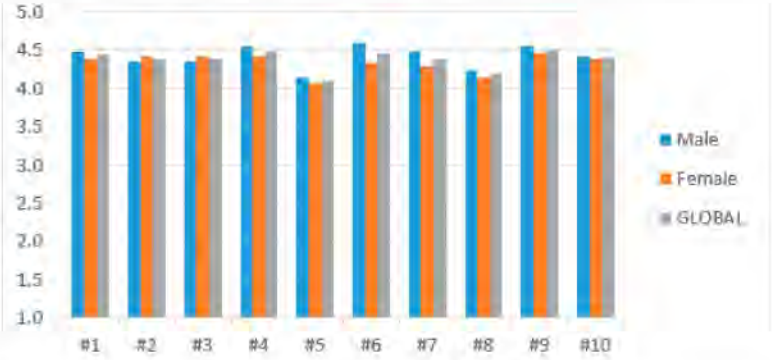

Figure 7. Comparison between male, female and global results in the professionals' group.

In the students' group and comparing the global results between male and female students, we did not find a significative difference ($p = 0.8262$) either, see Figure 8.

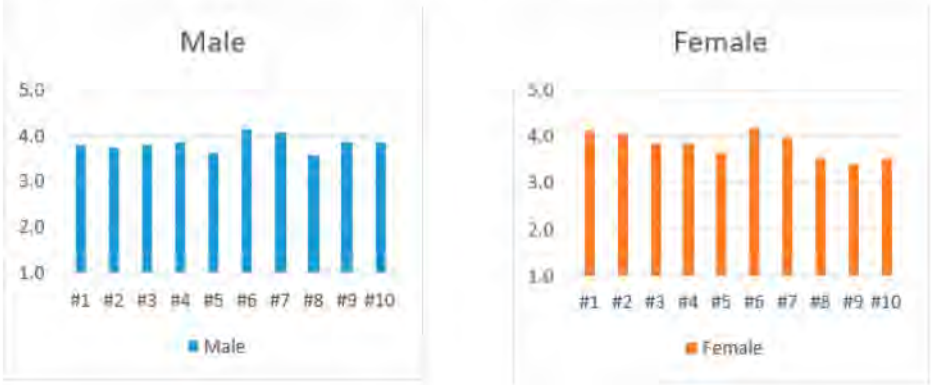

Figure 8. Answers of males and females in the students' group.

The lowest values was in statement #8 with a global average of 3.55 (SD: 0.99) followed by #9 with an average of 3.63 (SD: 0.90), while at the opposite end we found statements #6 and #7 with averages of 4.16 (SD: 0.74) and 4.01 (SD: 0.68)), as shown in Figure 9.

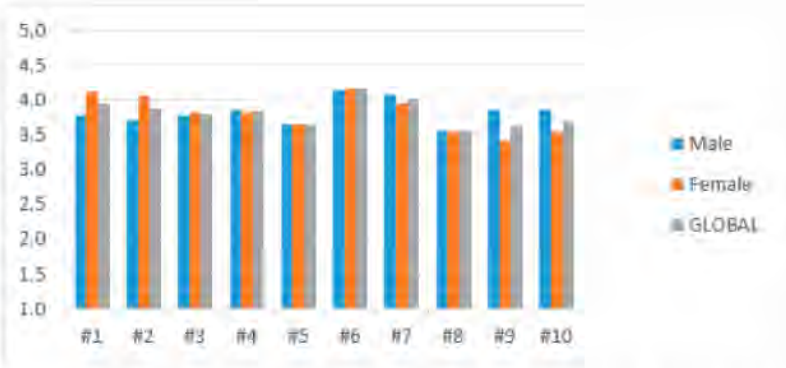

Figure 9. Comparison between male, female and global results in the students' group.

When we grouped all professionals together and all students together, the first relevant fact was that the differences between the two groups were statistically significant ($p = 0.000$), which indicated that both groups had clearly differentiated responses as shown in Figure 10.

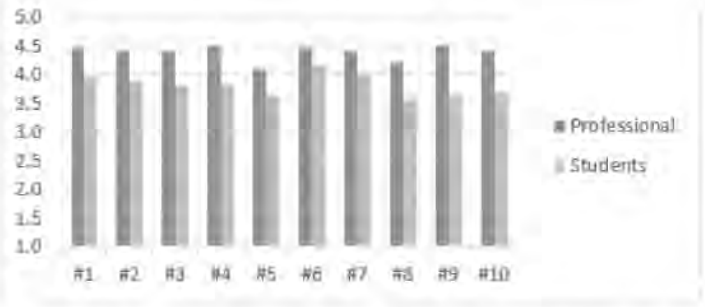

Figure 10. Comparison between the professionals and students' group.

The global level for the professionals surveyed, regardless of gender, stood at 4.44 (SD: 0.12), while for students, the overall value was significantly lower (Av: 3.82, SD: 0.19). While the lowest values were grouped into the statements #5 and #8 for both groups, confirming these statements as the perceived ones of less importance and impact at both the educational and professional level. The highest values were distributed differently between groups, being #9 (statement with the greatest difference between groups, of 0.87 points) and #4 for professionals and #6 and #7 for students. The statements were more similar as averages (both with differences that were not statistically significant).

Differences by gender from the same age group were minimal, and there was no gender gap in the use and potential perceived utility of the systems studied, as well as the improvement for compression of the space. However, the age gap was very clear. Professionals saw these systems with great potential and usefulness, while students still did not value them.

4. Discussion

After collecting the results, we noticed limited variation in the answers, in terms of gender, having a small difference between them. This aspect was not a variable in this case, in opposition to other case studies [44] where the answers by gender showed a significant difference. Based on this, we can conclude that in the case of studies the gender does not cause any variations. The second comparison that shows slightly differences is the comparison by background. The differences were not very high, but still represented how the stage in career affects the way they agree on the usefulness of a method.

By offering architecture students and professionals new ways to participate in the process of design, they can better visualize and understand physical projects, which allows them to develop both the dimensional and ergonomic relationships between elements, as they see their designs come to

life in real time. It is possible that virtual reality applied in design and local government contexts, might change the way we conceive urban development and planning, even allowing users to think in a 'greener', ecologically-friendly way.

Based on our hypothesis, we can say that gamified strategies for the understanding of three-dimensional space facilitate the acquirement of urban spatial competencies. The use of digital interactive systems in the educational process of urban design courses, helps to improve digital skills in complex representation and allows for the re-evaluation of urban spaces. Regarding the learning aspects from the results and the information gathered on the principles about how people learn, presented in the introduction of this article, we can conclude that:

- Professionals valued the system higher than the students as professionals have more knowledge on the field and know what to do, and what they are connecting is only the how to do it, which is the with the VR system. Meanwhile, students are learning both things, the what and the how at the same time, rather than connecting both aspects with previous knowledge.
- There were more similarities within the students' group than within the professionals' group. The students that participated in the experience were all at the same level of their academic career, while the variation in the professionals' group was higher, as it depended on their professional specializations inside their fields.
- Professionals valued higher the systems that help them to transmit problems, solutions and ideas to both, the non-specialized and specialized, public. Students, valued higher the fact that this system helps them to understand the relationships between buildings and the space between them. The values were associated to those that were more used to working in their careers.
- It is evident that this tool, in general, was very well evaluated because of the interaction it provided to users. This was also found in previous tests [26,44].

Regarding the urban design process, the quantitative analysis reveals that both groups highly value the fact that the interactive VR system helps them easily identify needs and requirements of citizens, a scenario both groups have to work with during the first stage of any urban design process. It is confirmed, through the outcomes, that the use of VR in the design of urban environments improves spatial perception and urban competences and can be used as a method for educational purposes to help in the design process and its representation.

5. Conclusions and Future Work

Through this research, it was shown that teaching methodologies can be successfully tackled by using methodologies that adjust to the profile of the student, and just an important, methodologies that adjust with what is used in the professional field. The use of virtual reality in the educational process of urban design courses was demonstrated to aid in the acquisition of urban design competences. This not only revealed the practicality of the system, but also the potential in the academic improvement of the student. Still, a feature to be evaluated in the future is the fact that the participants gave a lower value to the statement that they would use it again in the future. Although the profile of current students is that of a user familiar with the use of technologies to communicate and represent ideas, there is still a gap between the potential of ICTs incorporation in classrooms and its actual implementation in the workforce. It is necessary to change the way these tools are introduced and explained in educational institutions, in order to reduce the gap between the educational sector and the professional sector. The latter seems to be more prepared to incorporate all kinds of technologies, interaction, gamification and different strategies. Our future research will focus on integrating this as a method in the teaching of urban design processes.

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writing—review and editing, M.V.S.-S., R.T.-K., and J.F.-S.; visualization, M.V.S.-S., and R.T.-K.; supervision, R.T.-K., D.F., and J.F.-S.; project administration, D.F.; funding acquisition, D.F.

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Virtual interactive innovations applied for digital urban transformations. Mixed approach

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HIGHLIGHTS

- Integration of Digital transformation into the visualization of Urbanism.
- Virtual Reality systems for participatory design.
- Technological innovations to improve motivation in urban decision-making processes.
- Informal data generated by the citizenship.
- DT in governmental urban design projects.

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ABSTRACT

The cities in which we live are changing rapidly, presenting the scenery to debate future visions of transformative designs and its impact on the city. In order to take advantage of the changes and opportunities offered by the inclusion of digital technologies, an accommodation of the digital transformation into the visualization of Urbanism is required. It is a challenge for organizations and society to question the *status quo* and experiment often. The discussion about the increasing integration of digital technologies in urban spaces involves a number of questions relating to the complex processes of transformation that impact cities, like economic, social, political, and environmental. The main goal of the paper is to present the use of Digital Transformation in processes of urban design through technological innovation in which the diverse forms of active citizenship operate from below as agents of innovation, inclusion and social development. The results showed that it is possible to empower Digital Transformation – as for example the use Augmented and Virtual Reality (AR/VR) systems in collaborative urban design – to improve public motivation, implication, and satisfaction in urban decision-making processes.

1. Introduction

In Urbanism there are four significant themes: (1) is for and about people; (2) the value and significance of 'place'; (3) operates in the 'real' world, with its field of opportunity constrained and bounded by economic (market) and political (regulatory) forces; and (4) the importance of design as a process [1]. It is about constructing a scenario for urban evolution, imagining the conditions of transformation and proposing a process capable of incorporating new experiences into the human–environment relationship. Using technological innovation have an effect on the mode through which social movements and the diverse forms of active citizenship operate from below as agents of innovation, inclusion and social development [2].

In the last decade, there have been various initiatives conducted by researchers as well as all type of organizations to explore methods and technologies to foster the public participation in the design and implementation processes of social projects. One of the strategies, increasingly used, has been the implementation of these projects through new digital media. However, the use of new tools has not generated a digital transformation (DT) as was expected, among other things because of the novelty of the proposals, or even because of the use of technologies that are not commonly used by users [3]. This lack of success in technologically innovative proposals is due in part to an insufficiency of motivation on the part of the user, which, together with a lack of experience in the use of tools, condemns the proposals for transforming organizations into innocuous efforts. For this reason, technological innovations must

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be accompanied by a methodological innovation, which above all, generates greater motivation on the part of organizations and users. In this sense, it is increasingly common to find proposals that base their initial efforts on methods such as gamification, to adapt content and technologies to the needs and requirements of users.

Taking advantage of technology from the visual simulation and virtual reality, provide a delivery system for organizations to get closer to final users. Virtual reality has rapidly become one of the most exciting new computer technologies — exercising a strong hold on the popular imagination, attracting hundreds of researchers, and spawning a booming industry [4]. Working on the spatial transformation virtually is a supporting dimension of the overall process of a structural change. We are in the need of new collaborative design processes, adapted to the new social, technological, and spatial context in which we live.

This article describes the role and use of technological innovations in DT involving the social re-appropriation of urban spaces and contribute to social inclusion in the city of Barcelona. It is focused on studying the motivation, engagement, and overall experience of the participants with the technology. For this purpose, we have designed a mixed evaluation method (using quantitative and qualitative data), which allows us to identify the positive and negative aspects in a more objective way. The general objectives (or research questions) of this paper is to approach the following topics:

- Combining model with real-scale proposals using Augmented and Virtual Reality in open spaces makes, is it possible to define a new space-participation model, guided, on the local scale, by single citizens, and by a local community.
- It is inferred that these initiatives could facilitate public decisions through the social re-evaluation of spaces, real and virtual, in order to respond to unsatisfied needs.
- Organizations can be able to incorporate informal data obtained from citizens, urban and architecture professionals, students, and consequently, designs can be executed with a suitable design, adapted to space and combining the functionality, needs, and interests of all of them.

The Section 2 of this article, analyzes the framework related to the way Urbanism is practiced to see later on how technologies are incorporated. Section 3, includes the explanation of citizenship participation in the inclusion of digital technologies inside of an organization and exemplified the use of digital transformation in Urbanism through new ways of Urbanism. Section 4, presents the project. Section 5, discusses the data obtained from the mixed assessment, leading to the conclusions and future work of the study, which are discussed in Section 6.

2. A new challenge for Urbanism

Urbanism theoretical maturity was reached in the twentieth century from a combination of different disciplines that merged to rethink the city. It was a time when specialists in the field started to study more about the problems of our cities adopting new methods of research and analysis, emphasizing more in the scientific phase than the artistic one. "This may be due to a natural reaction against past practice when city planning was based on the superficial *city beautiful* approach, which ignored the roots of the problems and attempted only window- dressing effects". – Jose Luis Sert [5]. Urbanism developed as a new science; concerned with the structure of the city, its process of growth and decay [5]. The physical, social and cultural changes that we are experimenting force the contemporary urbanist to a practice open to the processes of socially responsible participation and the conscious interaction of the culture that live- in each place.

In Urbanism current technology-driven implementations, while being an important step is important to understand that the main actors are the people and the human dimension of cities. For this, the conception of a participatory innovation system in which citizens and communities interact with public authorities and knowledge developers is key. This collaborative interaction leads to a co-designed user-centered innovation models of governance. The urban transformation in which citizens are the main "drivers of change" through their empowerment and motivation ensures that the major city challenges can be addressed, including sustainable behavior transformations [3].

To merge the main actors of the cities with the spatial forms and processes it is understood to be necessary to adapt to the new social, technological, and spatial context in which we live. Technologies, methodologies and tools for these urban processes are various. Even processes that are now a common instrument, like the computer, have opened a new world to the Urbanism, through new forms, new perspectives and new ways of analyzing data. Psychosocial and post-occupational studies, new communication media and ways of collecting data and technology that can detect social, economic and environmental patterns of the urban spaces, is supporting the discipline and bringing another dimension to the practice. Also in the visualization aspects, the approach of Visualization and understanding of 3D, which typically accomplished via the classical view is changing due to a generational change and the continuous improvement and development of technology [6].

Present and future changes that are leading to the necessity of a faster utilization of a DT strategy, can be brought by several causes like users' behavior and expectations, new economic realities, societal changes and emerging digital technologies [7]. For this, DT has the capability to renovate a sector's activities, processes, competencies, and models to force the changes and opportunities of a mix of digital technologies and their accelerating impact across society in a strategic and prioritized way, with present and future changes in mind. Sectors that are involved in tackling societal challenges such as urban deterioration and unpractical city spaces, can take advantage of one or more of the existing and emerging technologies. Using technological innovation have an effect on the mode through which social moves and the diverse forms of active citizenship operate from below as agents of innovation, inclusion and social development [2].

Combining the innovative technologies to reach citizen participation in decision-making about the construction of the city is an essential condition for urban ecological regeneration. The act of "urbanizing" a project through DT requires a vision for what parts of the process need to be transformed. In face of the enormous amount of urban data that is needed to develop a proposal, the field of Urbanism is yet to incorporate many sources of information into their workflow. Whether it is in the way students are trained and professionals work and collaborate, the way processes are executed, or in the way, it relates to the users, digital technology provides a meaningful opportunity. Regardless of the enormous amount of urban data to incorporate, representation technologies bring ideas into reality, allowing communication between designers, clients, contractors and collaborators [8]. This is the same as for the professionals in the field and organizations should commit to incorporate these technologies.

3. Social in DT

Currently, the ways we communicate have been changing and adapting to new devices and applications that mostly involve characteristics such as mobility, interaction and interconnection. [9] describe 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". Informal data related to a public space that analyze semantic, temporal and spatial patterns, aspects generally overlooked in traditional approaches, improve the process of urban designing and management in order to relate the projects to the main needs of the citizenship. Through DT, organizations should be able to incorporate informal data obtained from the space, to develop more sustainable projects and products adapted to more users and/or users with different profiles or disabilities. The need to incorporate an informal approach to projects used by the public is essential. For this, the use of the gamification of a real space generates a virtual space and an urban environment of simulation in which it is possible to make dynamic experiments of participation and generation of ideas, uses or changes that improve that space [10].

Gamification has been put forward as a tool to support the process of civic participation that leads to sustainable civic engagement through a process of collective reflection [11]. This tool citizen enables citizens to observe their environment and reflect collectively on spatial issues in their daily environment. There are references to the use of gamification in urban planning processes linked to other citizen participation such as the "Blockholm" - Stockholm, 2014-, a game based on Minecraft promoted by the Swedish Center for Architecture and Design of Stockholm that has invited 100,000 users, technicians and experts in urban design and citizens to participate. Other examples are the "Play the City", from the Play the City Foundation implemented throughout 2012 in different cities of Holland, Belgium, Turkey and South Africa and which was based on a Word of Warcraft type game, or the use of the "SimCity" game in its different versions in urban planning workshops, highlighting the case of Cape Town in 2013.

They are basic proposals for zoning, for general uses at the level of an entire urbanization, or for large-scale digital work. In the significant case of Blockholm, informal teaching model is applied since it is the citizen who generates a series of opinions or suggestions for change that reaches the students externally since the whole process is outside the academic scope. The same happens in the cases of SimCity or Play the City, where part of the results revert to contents of informal use in the student's training but are more focused on specific practices of professional projects. In this sense, this experience is the closest to our approach, given that we have defined challenges to be solved by users and that generate complementary information prior to the generation of the project, knowing the type of participants, their opinions modifying the scenario and it can be interpreted as the support or rejection of a proposal.

Using new technologies, as for example VR and AR, we can work with defined urban proposals rehearsing various strategies of action in an interactive way and collaboratively evaluate public spaces. It is important to take into account how the VR is a technology, that applied correctly, can be a tool to involve society and democratize decision making in complex projects, like urban ones. Taking into account that the basis of the VR is to create an immersive experience and allow the user to interact with objects.

4. Case study

The urban project we work on, promoted by the Barcelona City Council, aims to create a large public space that prioritizes the people of the Eixample Esquerra District instead of the vehicles (Figs. 1 and 2). They want to generate spaces that are designed to meet the needs of the users: spacious, pleasant spaces full of vegetation with dynamic uses and according to the needs at all times. According to their criteria and collaboratively, configuring elements such as spaces for children's games, urban gardens, vegetation, lighting, recreational and cultural activities, among others. They stated the following conditioners:

- Address the street primarily to pedestrians
- Prevent spaces for stay and neighborhood coexistence
- Increase the low vegetation while maintaining the alignment of trees typical of the Eixample
- Increase the surface of rainwater catchment on the terrain
- Establish criteria for the location of furniture and services (garbage bins, cargo download, bar terraces...)

For this, we created a virtual reality game in which through interactive elements, the participants shaped the urban public space. We exposed to the public to use "wearables" technologies such as RV glasses and RA in Tablets to know how virtual reality can help us to participate in a city-planning restructuring project in our city, such as the Superilles (super squares) in Barcelona (Fig. 3). The testing of this technology includes both, quantitative and qualitative techniques, with the variable of a gamified proposal and the use of visual technologies, aspects that brings innovation, and immediacy. The focus of this testing is to study the motivation, engagement, and overall experience of the participants with the technology, more than the effectiveness of the approach, as the whole urban design process has not been completed, and still ongoing.

The objective is to bring all citizens the technology of virtual reality so that they can participate in the definition of the uses of the public spaces of the city of Barcelona such as the Urban Mobility Plan Superiors (PMU) 20132018, and help to build the city that we all want in a participative way. At the end Barcelona City Council (organization interested) wants to create a space that prioritizes the people, designed to meet the needs of the users, then is the people who have to collaborate to achieve this goal. This methodology brings the participants as an active element of the project, able to preview the space, propose changes and be part of what later on will be a livable space.

The virtual reality allowed participants to see in an immersive way the changes and actions that happen in the environment in real time (Fig. 4), for example, in the calculation of specific lighting in a space to show a very dynamic and realistic result. Some participants' proposals, inserted into the simulated environment, have the capacity to be in constant interaction by moving and rotating actions. The procedure that the participants followed was:

1. The explanation of the project was exposed and so the description of the experiment, the technology and the way they would take part in the project;
2. The way to use the tool was to explain, for example, how to use the controls, how to move on the space, how to grab objects, how to move and rotate the objects, how to choose them from a catalog and how to see the cost of each object;
3. The controls and the helmet are given to the participant to start the using the tool, get immersed in the virtual world and start to get familiar with the navigation system;
4. The participant is exposed to a pre-built environment, with all the existing buildings already in the site, and they get to see the catalog with all the options of objects;
5. Participants have already identified their necessities. In our case, taking into account the limited time of the test, we have proposed one challenge: to create a summer cinema in the street, choosing objects that are organized in categories with a limited budget;
6. Participants start to interact in the space, moving to the specific place they want to propose a use and grab the objects they want, drop then in site and move and rotate them to the exact position they want;
7. When participants are choosing the objects they get to see the price of each object.

Fig. 1. Urban project first proposal.

Fig. 2. Comparison of present state and future proposal.

Fig. 3. Fair Research in Direct 2018. Multimedia gallery. https://recercaensocietat.wordpress.com/galeria-multimedia/. Accessed on May 7, 2018.

An interesting feature of this tool is that participants get to see what they are proposing in real time. Objects throw shadows, the participant get to choose if the environment is seen in daytime or nighttime and see in real time the lighting being put on any section of the street and how it is affected by the color, intensity or type of light being used, they get to see a real-time map while they are moving through the space to see their situation within the city and have a visible pointer that select the objects and select the options in the menu (Fig. 5). This method allows the participant to see in a very immersive way the changes and actions that happen in the environment in real time. The rendering engine, Unreal Engine 4, allows the calculation of these features in a space to show a very dynamic and realistic result.

The behavior of a user of a new system or proposal provides information crucial for the success of its final implementation. In the experimentation and scientific research, if we work with

Fig. 4. Example virtual reality scene.

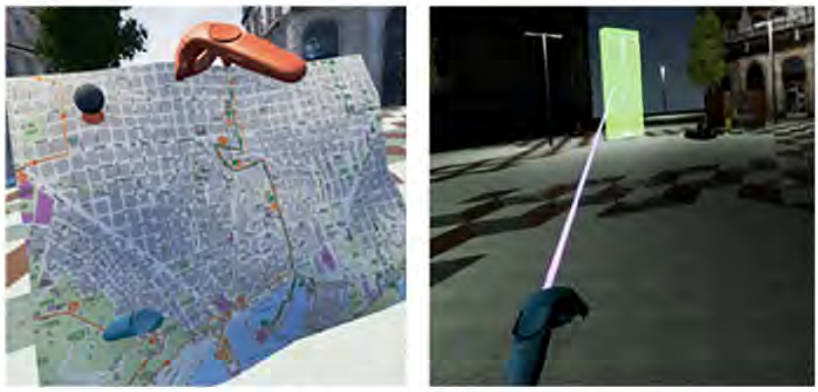


Fig. 5. Example virtual reality scene.

many samples (a minimum of 30–50 samples), we can manage collected data quantitatively and the results can be studied and compared in order to find statistical differences. With fewer users (less than 10), however, the qualitative approach has proven to be equally valid with the ability to obtain a detailed explanation of the variables of the study [12]. In this frontier, a hybrid approach to experimental methodology has emerged: the mixed-methods research approach. We can define the mixed method research as the natural complement to traditional qualitative and quantitative research [13,14]. This model is based on a pragmatic paradigm that contemplates the possibility of combining quantitative and qualitative methods to achieve complementary results.

5. Results: data and discussion

To collect data, we conducted two experiments: In phase 1, experimentation was carried out in the framework of the Fair Research in Direct 2018 (with the data discussed in Section 5.1) and in phase 2 (Section 5.2), we replied the same experiment in the framework of the Architecture School of La Salle, Ramon Llull University. The purpose of this separation was to be able to compare the results by the user's profile and identify the assessments, perceptions and needs according to this.

5.1. Phase 1

For the quantitative approach, we delivered the participants questionnaires after using the virtual, the augmented or both proposals (which is based on previous experiments done in architecture educational framework, [6,15]). In the first block, we obtained personal information (age and sex) which pointed out: 46 women under 18 years old (mean age of 15.52 years with a standard deviation (SD) of 1.17), 70 men under 18 years old (mean age of 15.18, with a SD of 1.28), 6 women over 18 years old (mean age of 25.83, with a SD of 9.41), and 13 men over 18 years old (mean age of 23.40, with a SD of 9.09), for a total of 135 participants. In the second block, we design a Likert scale where participants evaluate the answer from 1 to 5 their level of agreement with the statement exposed. The participants were consulted using 13 statements about different aspects: seven related to Intrinsic Motivation Inventory (IMI#), three questions focused on the social view of the citizens (Soc-Urb#), and the lasts three questions related architecture framework and digital skills (Dig-Sk#):

- IMI1: I like and have fun using virtual environments
- IMI2: I understand the space better with 3D visual systems rather than with plans and models
- IMI3: Using virtual and gamified systems requires less effort to understand
- IMI4: The use of interactive systems generates less stress than traditional systems
- IMI5: By knowing the new visual systems, will change my way of working in the future
- IMI6: Games and interaction are useful for my future and can benefit me
- IMI7: These systems help me to interact with other users/friends/colleagues
- Soc-Urb1: These systems facilitate decision making in urban projects
- Soc-Urb2: The RA/RV systems allow the design and re-evaluation of urban spaces
- Soc-Urb3: They allow to identify possible unsatisfied social needs

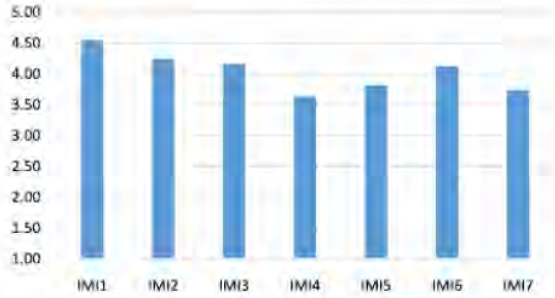


Fig. 6. Intrinsic Motivation Inventory questions about the use of virtual systems in urban spaces.

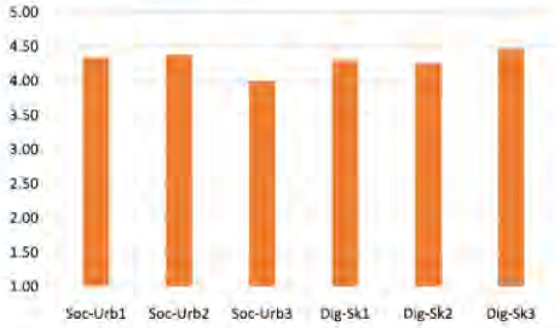


Fig. 7. Usability of Virtual Systems for Social/Urban proposes and to improve Digital Skills of the students.

- Dig-Sk1: With the information obtained from the users, the students can incorporate the data to optimally modify their projects and proposals
- Dig-Sk2: The opinion of the final users helps and should serve to improve the training /competences of the student
- Dig-Sk3: These systems help to improve the digital skills in a complex representation of students

Focused on the theme of the Project (based on the design and virtual interaction of new proposals for the use of urban space and the adaptation to the space of both proposals and users), the data collection made in this article is significant as identifies a series of variables to pay attention in the process of system development. The 95% of users had never used an interactive VR system, and the remaining 5% had only used it for basic visual exercises. This data is interesting because, in previous studies (CINAIC), the absence of a previous use had been reflected with a reduced initial motivation, with an IMI of 3.0, which increased significantly once the system was used, reaching 3.9, taking into account that the sample was composed of architecture students.

By graphically analyzing the average obtained responses related to technologies used and perceptions/motivations, we observed similar behaviors in the four groups with high motivation, but with three levels below 4, with a margin of improvement IMI4 (3.64), IMI5(3.82), IMI7(3.74) (Fig. 6).

In the present study, with users outside the architectural field, the IMI average stood at 4.03, without significant differences at a global level neither by age nor by gender. This result is encouraging since it allows us to affirm that with the adequate training and practice time students can increase their degree of motivation in the use of interactive RV systems, and therefore a better preparation for the transversal use of them. Regarding the variables associated with the social/urban uses (identified with the questions marked as Soc-Urb#), and the improvement of digital skills in the students (identified as Dig-Sk# questions), the overall balance is satisfactory, all indicators are equal or above 4 (Fig. 7).

These results demonstrate a highly positive assessment by users regarding the issues designed. The average of the questions related to the utility of the system for the decision-making and re-planning of urban uses (Soc-Urb questions), have an average of 4.24/5. Higher is the result (4.34/5) related to the perception that these systems are an educational help to improve the digital and spatial competences of the students.

We have also analyzed and compared the responses by gender. To estimate the probability that the groups were significantly similar, we used Student's t-test with the null hypothesis (H_0) of no differences in mean scores between the groups. Statistical significance (two-tailed) is 0.077, which exceeds the threshold of 0.05, which means that there is a very low probability (minus that 5%), that the groups are different in their general assessment of all variables studied. The null hypothesis, which states that there

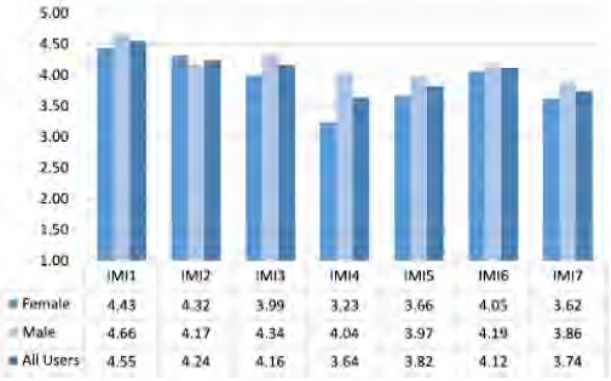


Fig. 8. IMI results by gender.

are no significant differences between groups (male and female), is accepted, but in a detailed way, we find some statically differences. The most relevant are:

- IMI-4 "*The use of interactive systems generates less stress than traditional systems*" detects significant differences between genders. Using the same comparative system as in the previous comparison, and with the null hypothesis (H0) that there were no differences in mean scores between the groups, we found that the statistical significance (two-tailed) was 0.0001, below the standard threshold of significance of 0.05. This result indicates that there was a significant difference in the responses between young female (with an average of 3.38, and SD of 0.92), and males (average of 3.73 and SD of 1.03), as occurs with adult sample (with a female average of 2.83 and SD of 0.16, in front of male average of 4.30 and SD of 1.06), and we can see grouped in Fig. 8.
- IMI-7 "*These systems help me to interact with other users/friends/colleagues*", detects again a significant difference (two-tailed, 0.004) between boys (average of 3.52, SD of 1.41), and girls (average of 2.92, SD of 0.91), being again better perceived by the boys. A difference that does is not endorsed in adults as in the previous case (significant difference of 0.401).

These results related to motivation and how VR generates a differentiated level of stress by gender, an aspect that in the literature is defined as Dominance [16], has been previously referenced at various levels [17–19]. Some of these studies [20–22], position this behavior due to a habitual difference in the use of technological and virtual systems depending on the users, their motivations and their "game" preference, an aspect to take into account for the possible future configurations of the Project.

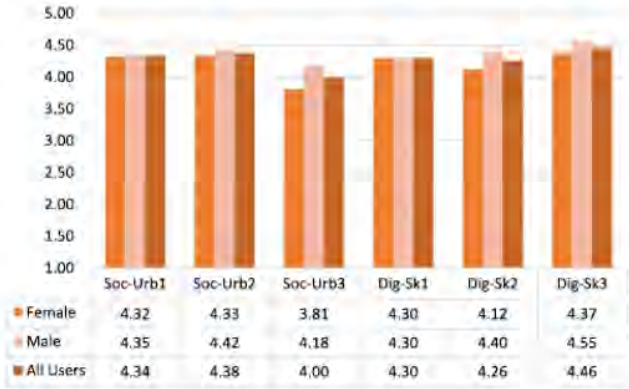


Fig. 9. Social/urban uses and improvement of digital skills using VR results by gender.

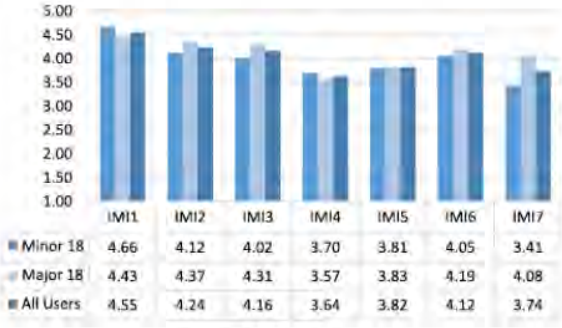


Fig. 10. IMI results by age.

• Regarding the variables associated with the social/urban uses (identified with the questions marked as Soc-Urb#), and the improvement of digital skills in the students (identified as Dig-Sk# questions) represented in Fig. 9, we have found only one significant difference in the SocUrb-3 "*They are allowed to identify possible unsatisfied social needs*" (0.040), with clearly higher values for adult men (4.46 with SD of 0.76), than women (3.66 with SD of 0.66).

Analyzing the responses by age (Fig. 10). Focused on the IMI results, the statistical analysis revealed that:

- IMI-3 "*Using virtual and gamified systems requires less effort to understand*", reflects a significantly higher value (0.044) between adults (4.42, SD of 0.81), and young people (4.02, DS of 0.79).
- IMI-7 "*These systems help me to interact with other users/friends/colleagues*", again, indicates a significant difference by age, with a higher score for adults (4.10, SD: 1.21), compared to the kids (3.43, SD: 1.41).

These differences show how VR systems allow an easy understanding of space and are perceived as systems that can enhance collaboration among users. This feature is clearly highlighted by older users, and that may potentially need systems and support aids for complex activities in digital environments, due to their lack of experience [23].

Analyzing the results of the social/urban uses and digital skills questions (Fig. 11), the main differences are:

- Soc-1 "*These systems facilitate decision making in urban projects*" reflects a significantly higher value (0.0025) between adults (4.57, SD of 0.25), and young people (4.12, DS of 0.65).

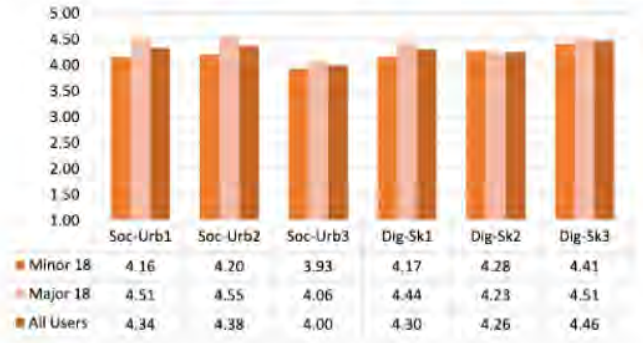


Fig. 11. Social/urban uses and improvement of digital skills using VR results by age.

- Soc-2 "*The RA/RV systems allow the design and re-evaluation of urban spaces*", again, shows a significantly higher value (0.0021) between adults (4.63, SD of 0.24), and young people (4.17, DS of 0.77).

On the other hand, the results of the social use variables show a clear differentiation between the needs and uses perceived by young people in these systems, and the "serious game" approach perceived by adults.

Based on the results obtained through the completed quantitative surveys, and in line with previous studies with mixed approaches, we completed a series of Bipolar Laddering interviews [24], to specifically identify relevant aspects, both positive and negative, of the experience that can explain the results obtained in the quantitative phase [25,26]. The BLA method works on positive and negative poles to define the strengths and weaknesses of a product. Conducting a BLA consists of three steps: Induction of the elements, marking of elements, and element definition. The questions "Why is it a positive/negative element?" and "Why this score?" are asked. The answer must include a specific explanation of the exact characteristics that make the mentioned element a strength or weakness of the product.

In this type of analysis, the Positive/Negative Common (PC/NC) elements are the most representative because they are the most cited (Table 1). Depending on the reference rate and its average obtained value, we can identify the most relevant elements. From the analysis of the qualitative interviews through the Bipolar Laddering the results are:

In Table 2, we can observe the comments identified by only one user (particular elements), and finally, in Table 3, we have grouped the main solutions and points of improvement. All these solutions were divided according to whether they were cited for more than one person (common improvements with its mention index), or only by one person (particular improvements identified by the user).

The analysis of the qualitative approach revealed that a majority of the participants experienced good sensations of reality and quality with the designed space (1PC) and its elements (5PC), with its movements (2PC), and with the designed interactions (3PC). In general, it could be defined as an enjoyable system (4PC). At the opposite extreme, the learning process (1NC) and the first moments are not as natural as expected. This is related to the understanding of the workspace (potential need for a map and the limits of work, 5NC), usability issues such as menu location or program jumps (2NC & 3NC), and the classic effects of dizziness associated with VR [27]. These negative aspects are directly related to the quantitative variable of lower valuation (IMI-4). In line with previous studies that show the relationship between negative emotional behaviors with visual aspects of new technologies, such as lack of quality, visualization distance, etc. [28].

Table 1
Main BLA Results: Positive Common (PC) and Negative Common (NC) elements.

	Description	Av. Score (Av)	Mention Index (MI)
1PC	Very Real Sensations	8.60	54%
2PC	Free movement	9.00	46%
3PC	Good Interaction	8.30	23%
4PC	Amazing	8.50	15%
5PC	Allow to perceive details of the objects	8.00	15%
6PC	Graphics quality	7.50	15%
1NC	Interaction and initials actions	5.50	46%
2NC	Punctual locks	6.50	15%
3NC	Menu location	5.50	15%
4NC	Sickness sensation	4.50	15%
5NC	Blank spaces without collisions	1.50	15%

Table 2
Secondary BLA Results: Positive Particular (PP) and Negative Particular (NP) elements.

	Description	Av. Score (Av)	User
1PP	Perspective sensation of space	9.00	User 6
2PP	Innovation	9.00	User 7
3PP	Usable in other frameworks	10.0	User 13
4PP	Analysis capabilities	10.0	User 13
1NP	Graphics quality	5.00	User 1
2NP	Lack of quality in general (pixelation)	3.00	User 2
3NP	Low reality objects	1.00	User 3
4NP	Static interaction, the user does not walk with reality	3.00	User 11

Table 3
Proposed common/particular improvements for both positive and negative elements.

Description	Mention Index (MI)
To improve the interaction with the objects and the space to reduce the learning time of the system	31%
To improve the quality or the graphics resolution	23%
To improve the reality of the objects	23%
More hardware/calculation powerful	User 1
Reduce the size of the location for a better understanding of scale elements and user movement	User 4
Add new interactive systems as for example gloves	User 10
Add characters in movement	User 11
Add the possibility to enter inside the buildings	User 11
Add keyword commands in a visible way for basic movements	User 12

After this testing, the results clearly identified that the aspects to be improved in the proposal are (see common aspects of Table 3) the improvement of the interaction with space and objects, the quality of the graphics and the reality of the objects. All of them are aspects that can be directly linked to the variables of social and urban use Soc-Urb1 and Soc-Urb2, variables with significant differences in their broken down study.

Undoubtedly, it is demonstrated that this mixed approach allowed us to more precisely identify the positive and negative elements of a working model. We depend on the participants to show where it is necessary to strengthen the experience to improve the results in future iterations of the method. It was validated that the younger participants, born into a "digital age" and defined as Digital Natives, adapted better to a high density of technological content in the educational environment.

5.2. Phase 2

However, after collecting the results and conclusions we noticed the limited variation of participants, in terms of age, having a majority of participants were under 18 years old, but particularly with a profile not related to the urban and architecture field. To consider the opinions and feedback of a more diverse population in terms of age and including participants that are trained or with experience in the conceptualization of urban planning, and the technological uses of digital applications, we made a second test, place at Architecture School of La Salle, Ramon Llull University. These participants had the same procedure to do the test than the first group that was tested in the Museum Cosmo Caixa Barcelona,

Table 4
Intrinsic Motivation Inventory questions about the use of virtual systems in urban spaces (CTII).

on the Research Fair in Direct. In this second group, the sample was Architecture students and faculty (identified as CTII – Computer Tools II): 15 women over 18 years old (mean age of 24.80 years with a standard deviation (SD) of 1.26), 14 men over 18 years old (mean age of 25, with a SD of 2.29), for a total of 29 participants.

In the second group (CTII), the IMI average stood at 3.64 (Table 4), without significant differences at a global level neither by age nor by gender. This lower result is related at first to the utility/complexity perceived by the system, based on the qualitative comments collected and not treated within this article. In summary, participants perceive a very powerful environment but with a long and complicated learning, without it being clear the immediate utility in the architectural and urban project process.

Table 5
Usability of Virtual Systems for Social/Urban proposes and to improve Digital Skills of the students (CTII).

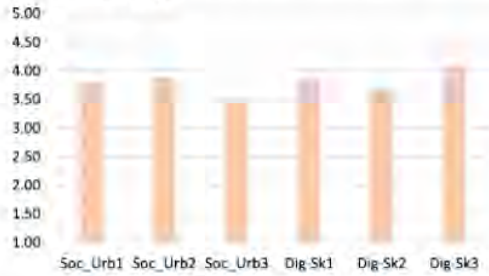


Table 6
Comparison IMI results.

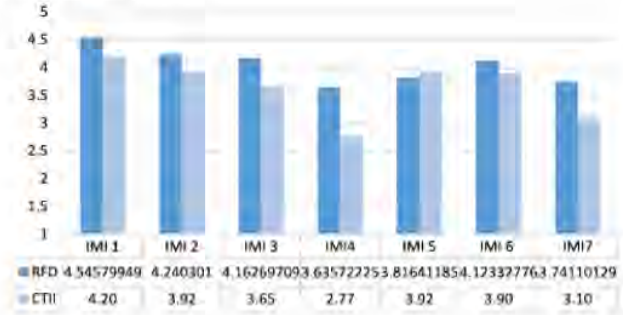
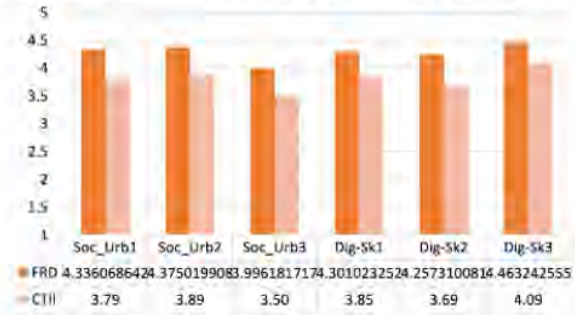


Table 7
Comparison of Social/urban uses and improvement of digital skills using VR results.



Regarding the variables associated with the social/urban uses (identified with the questions marked as Soc-Urb#), and the improvement of digital skills in the students (identified as Dig-Sk# questions) we found also lower levels in the group of CTII in front of the RFD sample. The average of the variables Soc-Urb# for the sample of the RFD is placed in a 4.27 with respect to the 3.73 of CTII, similar levels as for the variables Dig_Sk # (4.37 vs. 3.88 respectively) (Table 5).

We compared the responses of the two groups, RFD, and CTII, (Tables 6 and 7, using the Student's *t*-test for assessing the differences, and based on the null hypothesis (H0) of no differences in mean scores between the groups.

Based on the results (Statistical significance obtained below the threshold of 0.05, which allows to affirm a guaranteed difference of at least 95%), we can affirm that there is a clearly differentiated behavior according to the profile of the users of the system. Regarding the variables associated with the IMI test, we have found statistical differences in the variables # 1, # 2, # 4 & # 7, but in the case of variables associated with the social/urban uses (identified with the questions marked as Soc-Urb #), and the improvement of digital skills in the students (identified as Dig-Sk # questions), we have found statically differences in all variables. In Table 8 we can observe the results of the comparison between samples using the t-Student (based on different variances of the samples).

The clearly lower averages of the users related to the architectural educational environment can be attributed to factors such as a lack of initial motivation in systems that have not been previously used and over which they have not been trained. Also, can be a perception of lack of utility in their needs of the professional activity to which they add the perception according to these systems are agents closest to leisure or external uses of the architectural professional field.

On the other hand, and at a user level, systems such as AR or VR are technologies that we could curiously say are closer and less specific than more common tools as CAD (Computer Assisted Design) and BIM (Building Information Modeling) systems, that are the main technological tools used for modeling the architectural space, due to its fast learning curve, its high degree of implementation in subjects like workshop/projects/urban planning, and its constant use. This type of interactive technologies and with a certain gamified component is found increasingly common in all types of environments, ranging from early educational phases to all kinds of applications at play, tourism, culture, etc. Undoubtedly, this aspect is what most general users perceive as part of the potential of the tools evaluated and that is demonstrated in the high result of them.

6. Conclusions and future work

It is clear that the integration of DT as a tool in the process of the urban design generated positive feedback. The main innovation of this case study is the design of a practical system to recognize the informal data generated by the citizenship, and how by using a mixed method we can extract important data that can contribute to the government of Barcelona related to Urbanism. For this, it was validated, through the results that the implementation of a method can be used as a method for organizations to incorporate the opinion of the end-user and help to execute a suitable design, adapted to space and combining the functionality and interests of citizens. Furthermore, one of the purposes of this type of research is to show that city challenges can be more effectively addressed at the scale of neighborhood and to provide an example and experience that demonstrate with the participation of the people who live, work, and play in that space and shifts the emphasis from top-down concept to a human-centric problem-solving.

From this study is verified that the use of Digital Transformation in processes of urban design and citizenship, through innovative concepts and practical methodologies, such as AR/VR systems improve public motivation, implication, and satisfaction in urban decision-making processes. Participants were receptive and aware to adapt to this new paradigm using advanced visualization methods. From the results, we identify that it is a fun tool to use, that these systems help to improve the digital skills in complex representations and that they should allow the design and re-evaluation of urban spaces. This aspect reflects the usefulness of the method, the potential use in organizations and with stakeholders, and that it is possible to define a new space-participation model, guided, on the local scale, by single citizens, and by a local community. The end to show how to facilitate participatory design, the motivation, engagement, and overall experience of the participants with the technology, more than the effectiveness of the approach, as the whole urban design process has not been completed, and still ongoing.

However, an aspect to be re-evaluated is the fact that the participants gave lower point to the affirmation that this tool allows to identify possible unsatisfied social needs and to the affirmation

Table 8
T-Statistic and P (T< =t, two tailed).

Variable	*T*-Statistic	P(T< =t) two tailed
IMI1	2.676780947	**0.011235966**
IMI2	1.120234757	0.269294989
IMI3	2.041623043	**0.048367485**
IMI4	4.771683931	**2.13037E−05**
IMI5	−0.634710833	0.528569625
IMI6	0.894901021	0.376193604
IMI7	1.744822319	**0.044254121**
SOC 1	2.515225107	**0.015909398**
SOC 2	1.866614582	**0.034743524**
SOC 3	2.387306021	**0.021666007**
DSK 1	1.87053192	**0.034464041**
DSK 2	3.5101366	**0.001124552**
DSK 3	1.68816103	**0.050266944**

that the use of interactive systems generates less stress than traditional systems. For this, it would be important to improve the interaction with space and objects, the quality of the graphics and the reality of the objects. Our future experiments will be related with the study of the correlation between the interaction of the user and the visualization method and the way they can manage it to serve as a tool to satisfy their needs. In addition, we will focus our future proposals to integrate of Digital Transformation in the urban design through innovative concepts and practical methodologies to improve public motivation, implication, and satisfaction in urban decision-making processes.

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5 Conclusions

Throughout this research, we have observed that the use of digital interactive systems in the educational process of urban design, improves the re-evaluation of urban spaces. In areas of formal and informal education of collaborative urban design, our method improves public motivation, implication, and satisfaction in urban decision-making processes. Participants were receptive and aware to adapt to this new paradigm using advanced visualization methods. The results not only reflect the usefulness of the method in the Architecture academic field, but also it is possible to define a new space-participation model, guided, on the local scale, by single citizens, and by a local community. It was demonstrated that teaching methodologies can be successfully tackled by using methodologies that adjust to the profile of the student, and just as important, methodologies that adjust with what is used in the professional field.

The results are led by three main objective lines in order to verify our two hypotheses:

H1. The use of virtual-interactive systems for the understanding of three-dimensional space improve in **students** and **professionals** the perception of the comprehension of the space, generating greater understanding of the location conditions, dimensions and relationships of urban spaces, and defend the arguments of urban projects and interactively defined urban proposals rehearsing various strategies of action.

H2. The implementation of virtual gamified strategies in the field of urban design will generate improvement and motivation in **citizen participation** and **students** as it is a more dynamic, real and agile collaborative environment thanks to the immersive visual technologies as they critically evaluate the result of the urban design and make decisions.

Related to the **H1** and **H2,** we worked on the **Line 1** to analyse the concept of Urbanism as a discipline from the **training** to the **practice** and examine the use of ICTs in the training of courses related to urban design and prepare surveys to study the profile of the students

(technological and social aspects), as well as the degree of motivation in the use of technologies and their future applications. The outcomes (Monica V. Sanchez-Sepulveda et al., 2020) were in line with our expectations that the profile of the student was highly correlated with the motivation and satisfaction with the interactive system. The level of interaction of the students in all phases of the proposed methodology generated a high level of interest in visualization techniques and high learning perceptions.

Working with a collaborative and interactive interface and the capacity to generate physical and digital expositions are activities that produced active students with significant improvements in spatial, and interaction skills. The overall valuations of effectiveness and satisfaction were all approximately 4 of 5. Therefore, we can validate that the students felt satisfied and motivated when using this methodology.

This study has limitations that provide some variables to improve in future studies. Some of these variables are that, first, similar experiences between different courses must be compared to ensure that students' experience in other architectural subjects is relevant to their understanding of how to use the interactive technology. Second, the evaluation surveys and interviews need to be improved to collect more information about experiences throughout the entire course.

Related to the **H1** we worked on the **Line 2** to test the usefulness of digital tools in the **management of urban projects** related to the urban designer required competences. We evaluated the relationship of methodologies such as ICTs and gamification to the general and specific phases of the urban design, through professionals and students in the Architecture field and determine the correlation between motivation, satisfaction and experience of use, and the improvement of space.

The results (M. V. Sanchez-Sepulveda, Torres-Kompen, et al., 2019) showed that by offering architecture students and professionals new ways to participate in the process of design, they

can better visualize and understand physical projects, which allows them to develop both the dimensional and ergonomic relationships between elements, as they see their designs come to life in real-time. Gamified strategies for the understanding of three-dimensional space facilitate the acquirement of urban spatial competences. Regarding the learning aspects from the results (M. V. Sanchez-Sepulveda, Torres-Kompen, et al., 2019) and the information gathered on the principles about how people learn, presented in the Introduction of the thesis, we can conclude that:

1. Professionals valued the system higher than the students as professionals have more knowledge on the field and know what to do, and are connecting only the how to do it, which is the with the VR system. Meanwhile, students are learning both things, the what and the how at the same time, rather than connecting both aspects with previous knowledge.
2. Professionals valued higher the systems that help them to transmit problems, solutions and ideas to both, the non-specialized and specialized, public. Students valued higher the fact that this system helps them to understand the relationships between buildings and the space between them. The values were associated with those that were more used to working in their careers.

It is evident that this approach, in general, was very well evaluated because of the interaction provided to users. Regarding the urban design process, the quantitative analysis (M. V. Sanchez-Sepulveda, Torres-Kompen, et al., 2019) reveals that both groups highly value the fact that the interactive VR system helps them easily identify needs and requirements of citizens, a scenario both groups have to work with during the first stage of any urban design process. It is confirmed, through the outcomes, that the use of VR in the design of urban environments improves spatial perception and can be used as a method for educational purposes to help in the design process and its representation.

It was shown that teaching methodologies can be successfully tackled by using methodologies that adjust to the profile of the student, and just an important, methodologies that adjust with what is used in the professional field. Still, a feature to be evaluated in the future is the fact that the participants gave a lower value to the statement that they would use it again in the future (M. V. Sanchez-Sepulveda, Torres-Kompen, et al., 2019). Although the profile of current students is that of a user familiar with the use of technologies to communicate and represent ideas, there is still a gap between the potential of ICTs incorporation in classrooms and its actual implementation in the workforce. It is necessary to change the way these tools are introduced and explained in educational institutions, in order to reduce the gap between the educational sector and the professional sector. The latter seems to be more prepared to incorporate all kinds of technologies, interaction, gamification and different strategies.

Related to the H2 we worked on the **Line 3** to evaluate the usability, motivation and satisfaction of the serious games applied to the field of teaching of the urban project, citizen participation and involvement in the simulation of processes for decision-making and design. The profile of the end-users and students was evaluated, their motivation in the use of ICTs and finally their degree of satisfaction with the gamified systems used.

We found through the outcomes (Mónica Sanchez-Sepulveda, Fonseca, et al., 2019) that the integration of digital transformation as a tool in the process of the urban design generated positive feedback. The main innovation of this case study is the design of a practical system to recognize the informal data generated by citizenship. It was validated, that the implementation of a method can be used as a method for organizations to incorporate the opinion of the end-user and help to execute a suitable design, adapted to space and combining the functionality and interests of citizens. Furthermore, it shows that city challenges can be more effectively addressed at the scale of neighbourhood and to provide an example and experience that demonstrate with the participation of the people who live, work, and play in that space and shifts the emphasis from top-down concept to a human-centric problem-solving.

From the results (Mónica Sanchez-Sepulveda, Fonseca, et al., 2019) is verified that the use of digital transformation in processes of urban design and citizenship, through innovative concepts and practical methodologies, such as AR/VR systems improve public motivation, implication, and satisfaction in urban decision-making processes.

Participants were receptive and aware to adapt to this new paradigm using advanced visualization methods. We identify that these systems help to improve the digital skills in complex representations and that they should allow the design and re-evaluation of urban spaces. This aspect reflects the usefulness of the method, the potential use in organizations and with stakeholders, and that it is possible to define a new space-participation model, guided, on the local scale, by single citizens, and by a local community. The results present how to facilitate participatory design, the motivation, engagement, and overall experience of the participants with the technology, more than the effectiveness of the approach, as the whole urban design process hasn't been completed, and still ongoing.

However, an aspect to be re-evaluated is the fact that the participants gave lower point to the affirmation that this tool allows to identify possible unsatisfied social needs and to the affirmation that the use of interactive systems generates less stress than traditional systems. Due to this fact, it would be important to improve the interaction with space and objects, the quality of the graphics and the reality of the objects. Our future experiments will be related to the study of the correlation between the interaction of the user and the visualization method and the way they can manage it to serve as a tool to satisfy their needs.

The results are encouraging, since it allows us to affirm that the implementation of virtual gamified strategies in the field of urban design helps to critically evaluate the result of urban design, make decisions and understand the location conditions, dimensions and relationships of urban spaces thanks to enhanced visual technologies, corroborating the hypotheses. (Figure 22)

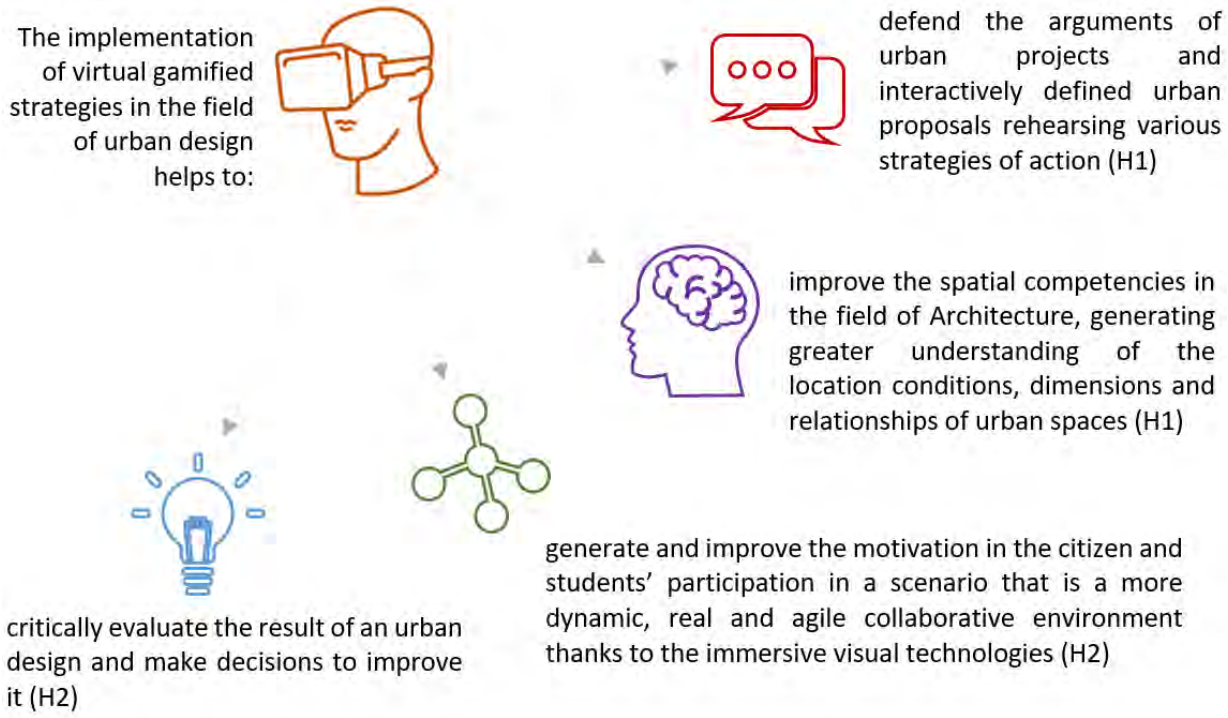

Figure 22: Conclusions based on the results.

By offering architecture students, end-users and professionals, new ways to participate in the process of design, they could better visualize and understand physical projects, which allows them to develop both the dimensional and ergonomic relationships between elements, as they see their designs come to life in real-time. This leads to one of the purposes of this research: to show that city challenges can be more effectively addressed at the scale of the neighborhood and to provide an example and experience that demonstrate in the Line 3 with the participation of the people who live, work, and play in that space and shifts the emphasis from top-down concept to a human-centric problem-solving.

It is demonstrated that the mixed approach allowed us to more precisely identify the positive and negative elements of a working model. The participants contribute to show where it is necessary to strengthen the experience to improve the results in future iterations of the method. In the end is shown that the virtual interactive system facilitates the participatory design, the motivation, engagement, and overall experience of the participants.

Based on the studies carried out and the results obtained, we believe that there are parts of our working hypotheses that have been validated and other parts where we believe that it is necessary to reinforce research in future lines.

The **H1** is partially validated. Is been validated that the use of virtual-interactive systems for the understanding of three-dimensional space improve in students and professionals the perception of the **comprehension of the space**, generating a greater **understanding of the location conditions**, **dimensions** and **relationships** of urban spaces, and **defend the arguments** of urban projects and interactively defined urban proposals **rehearsing various strategies** of action. However, **professionals** are more prepared to incorporate these kinds of technologies, interaction, gamification and different strategies than **students**. The gap that exists between the **potential of ICT's incorporation** in classrooms and its actual implementation in the workforce is evident and we are now in the process of studying it.

The **H2** is partially validated. Is been validated that the implementation of virtual gamified strategies in the field of urban design will generate **improvement** and **motivation** in citizen participation and students as it is a more dynamic, real and agile collaborative environment thanks to the immersive visual technologies as they critically **evaluate the result** of the urban design and **make decisions**. However, it is a tool that its best feature is not to identify possible social needs and can also generate stress that traditional systems don't.

Future lines of research will focus on: finding solutions for incorporation the ICTs into the academic methodologies, and the improvement of the visualization technologies for better performance. Our experiments will be related to the study of the digital gap division, and why we are still using classical methods rather than teaching and applying the actual and future methods to develop urban projects. The research will be oriented to the applicability of the knowledge and skills acquired, such as: usability studies, user experience and convergence with the professional field.

5.1 Work in progress

We are in front of a live research work and in a continuous process of data acquisition in order to design new teaching methods and systems that improve our current approaches. In this sense, and in order to establish a clearer relationship between the needs and motivations of students with academic requirements and even its modernization, we are already working on the analysis of data from surveys with students. We designed a continuous work focused on exploiting the potential of ICTs incorporation in classrooms and the renewal of pedagogical processes. It is necessary to know which methods and tools students are currently using, its limitations and the potential to be accompanied with other ICTs. The technologies students actually used in projects related to Urban Design in the studied institutions – UPC and La Salle URL – are diverse. We gather a list of different tools and methods used in both institutions:

1. Free-hand Drawing
2. Mock-up Model
3. Auto CAD
4. Lumion
5. 3D Max
6. Sketch Up
7. Rhinoceros
8. Unreal
9. Photoshop
10. Illustrator
11. BIM (Revit, …)
12. GIS (MAP, …)
13. Virtual Reality [2]
14. Augmented Reality [3]
15. Gamification [4]
16. Flipped Classroom [5]
17. Informal Learning [6]
18. Others

[2] Interactive computer-generated experience taking place within a simulated environment.
[3] Through a technological device, is added virtual information to the visualization of a physical environment of the real world.
[4] Learning strategy based on the dynamics of a game (prizes, category, rankings, ...).
[5] Blended modality. Use of face-to-face learning strategies (in the classroom) and virtual learning strategies (self-study in the home) with videos, pdfs, interactive presentations, etc.
[6] Self-directed learning or learning from experience.

The second step is to study different aspects that students have with these different tools they use in their academic career in general:

1. Level of knowledge
2. Degree of difficulty
3. Motivation
4. Creativity

The third step is to evaluate the system to link to the urban design project. The categories to evaluate are phases of the development of the urban project:

1. Situational Analysis
2. Schematic Design
3. Site/Program Planning
4. Construction Systems
5. Structural Systems
6. Installations Systems
7. Graphic Presentation

To evaluate the use of different systems a survey was designed and carried out with Architecture students from UPC and La Salle, URL to compare it to the different results. We design a Likert scale where participants evaluate answer from 0 to 5 the different concepts related to their career in general and specific to the urban design project. Participants were students from the 2nd and 4th academic years, to evaluate different stages in the Architecture academic career related to urban design projects.

From La Salle, URL we surveyed 70 students and from UPC we surveyed 82 students. All the results of the surveys have been computed and are in the process of study and analysis. A first comparison of the level of knowledge and degree of difficulty was made to 2nd academic year students from both universities. (Figure 24 and Figure 25)

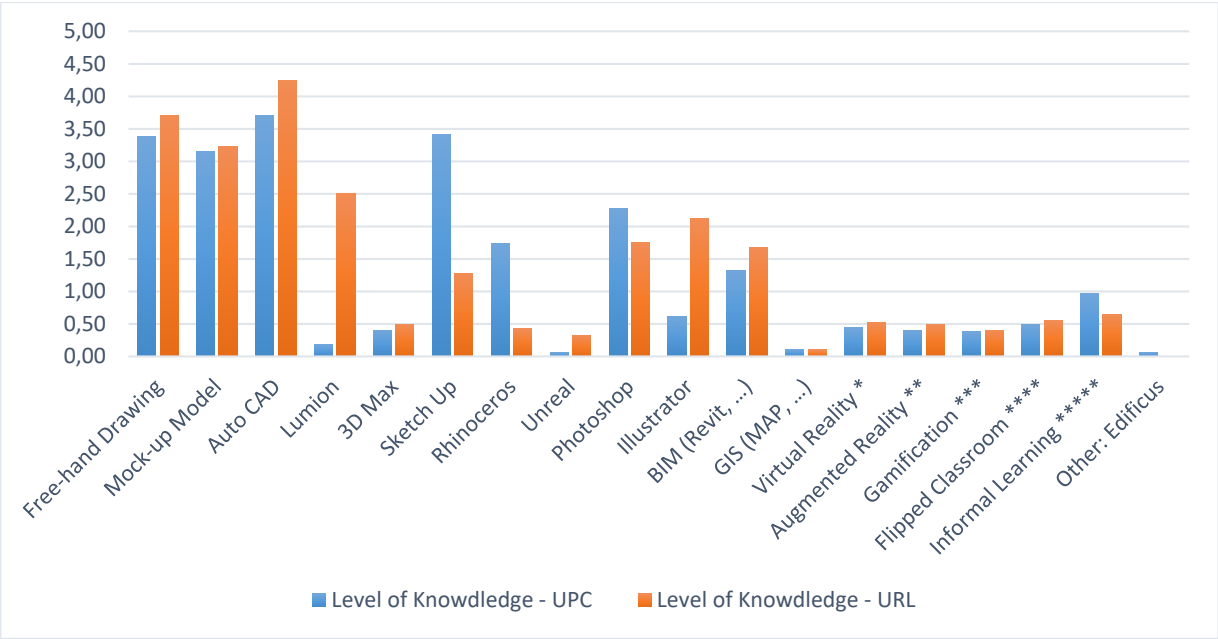

Figure 23: Comparison of the Level of Knowledge between UPC and La Salle, URL

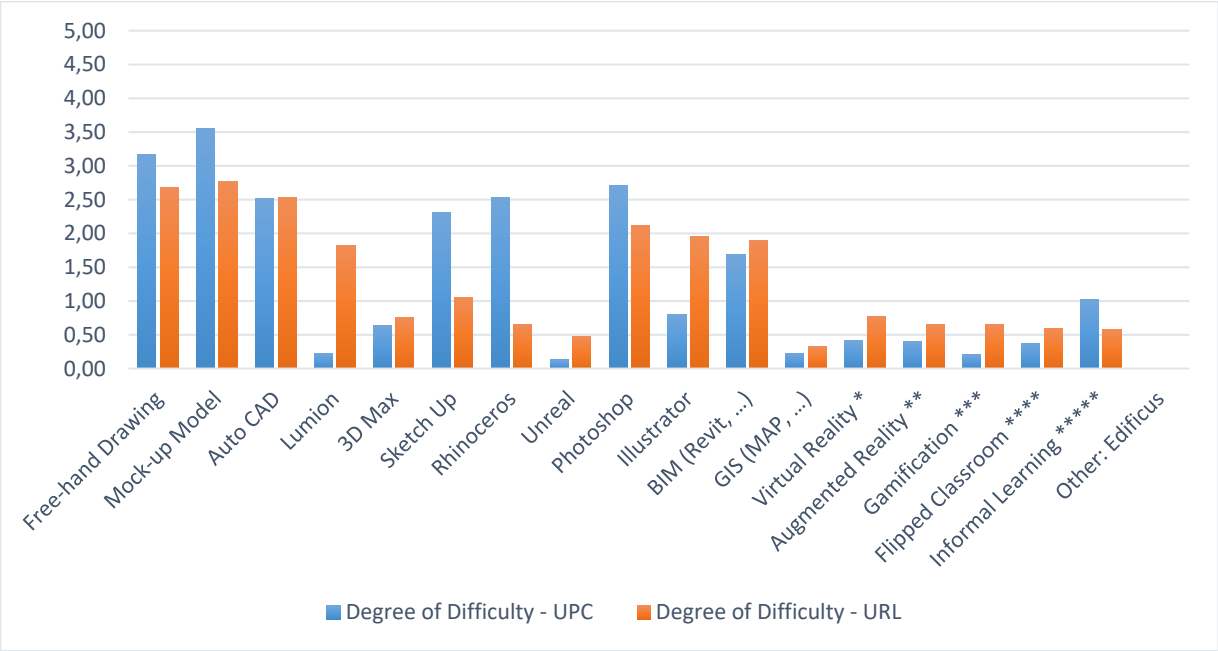

Figure 24: Comparison of Degree of Difficulty between UPC and La Salle, URL

To estimate the probability that the groups were significantly similar, we used Student's t-test with the null hypothesis (H0) of no differences in mean scores between the groups. For the Level of Knowledge statistical significance (two-tailed) is 0,86 which exceeds the threshold of

0,05 which means that there is a very low probability that the groups are different in their general assessment of all systems evaluated. The null hypothesis, which states that there are no significant differences between groups (UPC and URL), is accepted, but in a detailed way, we find some statically differences.

The average of the questions related to the Level of Knowledge has an average of 1,28/5 in UPC and 1,36/5 in URL. Higher is the result related to AutoCAD in both groups (UPC 3,71/5 with a standard deviation (SD) of 0,84 and URL with 4,25/5 with SD of 0,63). Lowest is the result related to Unreal in the UPC group and GIS in the URL group (UPC 0,06/5 with an SD of 0,36 and URL with 0,10/5 with SD of 0,30). The highest standard deviation for the Level of Knowledge in UPC is in Informal Learning, BIM and Photoshop (1,61; 1,56 and 1,52 respectively). Meanwhile, the highest standard deviation for the Degree of Difficulty is in Rhinoceros, BIM and Photoshop (1,98; 1,91and 1,75 respectively).

For the Degree of Difficulty, we also estimate the probability that the groups were significantly similar, with the null hypothesis (H0) and the statistical significance (two-tailed) is 0,92 which exceeds the threshold of 0.05, which means that there are no significant differences between groups. In an average of all the systems evaluated is 1,27/5 in UPC and 1,24/5 in URL. Higher is the result related to the Mock-up Model in both groups (UPC 3,56/5 with an SD of 1,13 and URL with 2,78/5 with SD of 1,59). The highest standard deviation for the Level of Knowledge in URL is in Lumion, Sketch Up and Illustrator (1,71; 1,52 and 1,57 respectively). Meanwhile, the highest standard deviation for the Degree of Difficulty is in Photoshop, BIM and Mock-up Model (1,70; 1,69 and 1,59 respectively).

By noticing that the Motivation and Creativity appear to be more similar between them, meaning that the level of creativity that the system provides links with the motivation it gives (and vice versa) it was jointly compared also both groups of students (Figure 26 and Figure 27). In Motivation and Creativity, the highest is the result related to Free-hand Drawing in the UPC group with 3,44/5 with SD of 1,38 in Motivation and 3,52/5 with SD of 1,30 in Creativity. The

lowest is also for both, Motivation and Creativity, given the lowest is the result related to Illustrator in the UPC group with 0,87/5 with SD of 1,72 in Motivation and 0,88/5 with SD of 1,69 in Creativity.

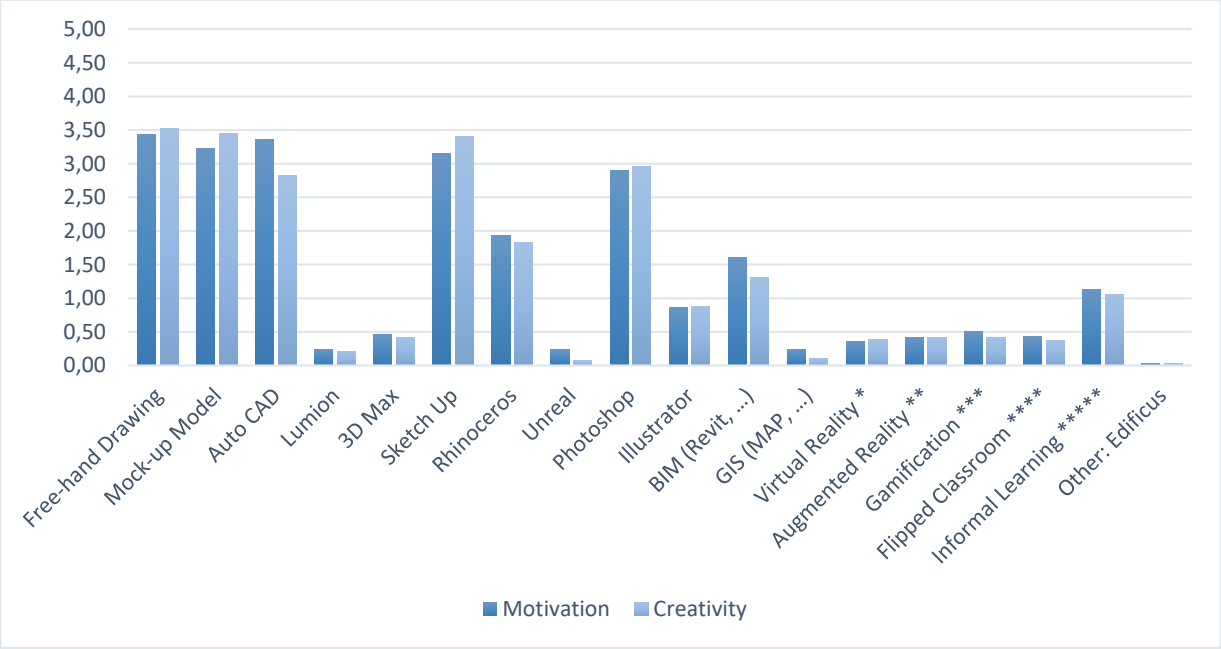

Figure 25: Level of Motivation and Creativity – UPC

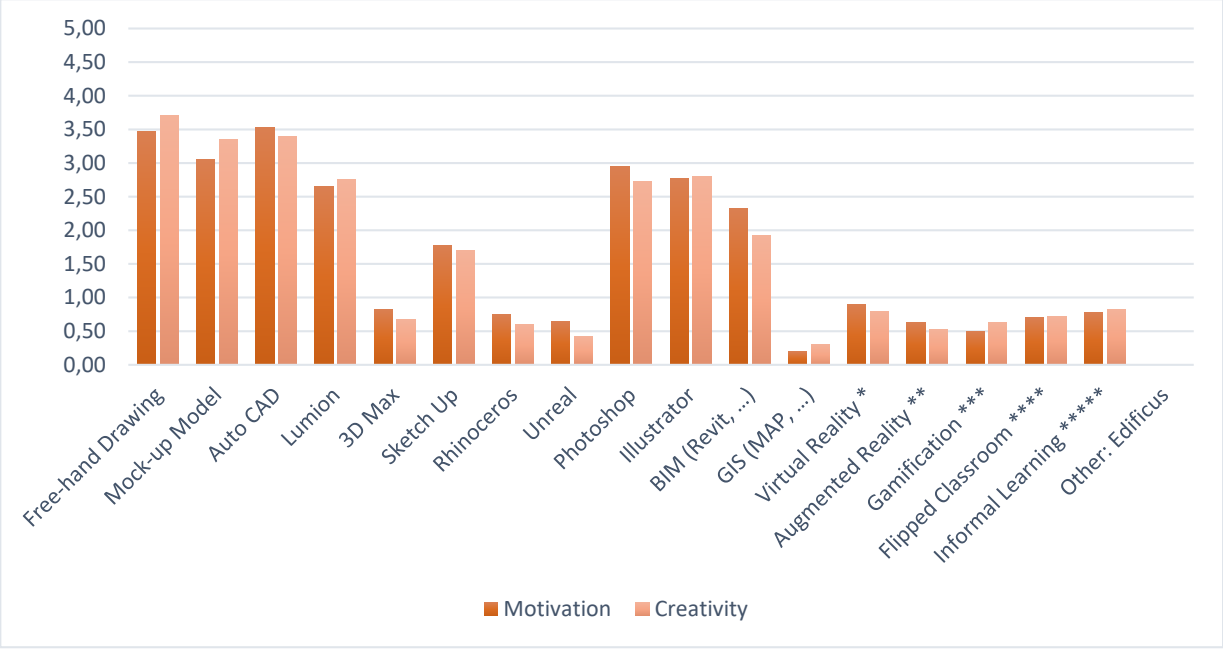

Figure 26: Motivation and Creativity – La Salle, URL

Meanwhile, for the URL group is not equally given the highest points for the same system. In Motivation, the highest result is for AutoCAD with 3,53/5 with SD of 1,24 and the highest result of Creativity is for Free-hand Drawing with 3,70/5 with SD of 1,32. The lowest is also different in the Motivation questions, giving the lowest in Motivation to 3DMax with an average of 0,83/5 with SD of 1,55 and the lowest in Creativity is Virtual Reality with an average of 0,80/5 with SD of 1,60.

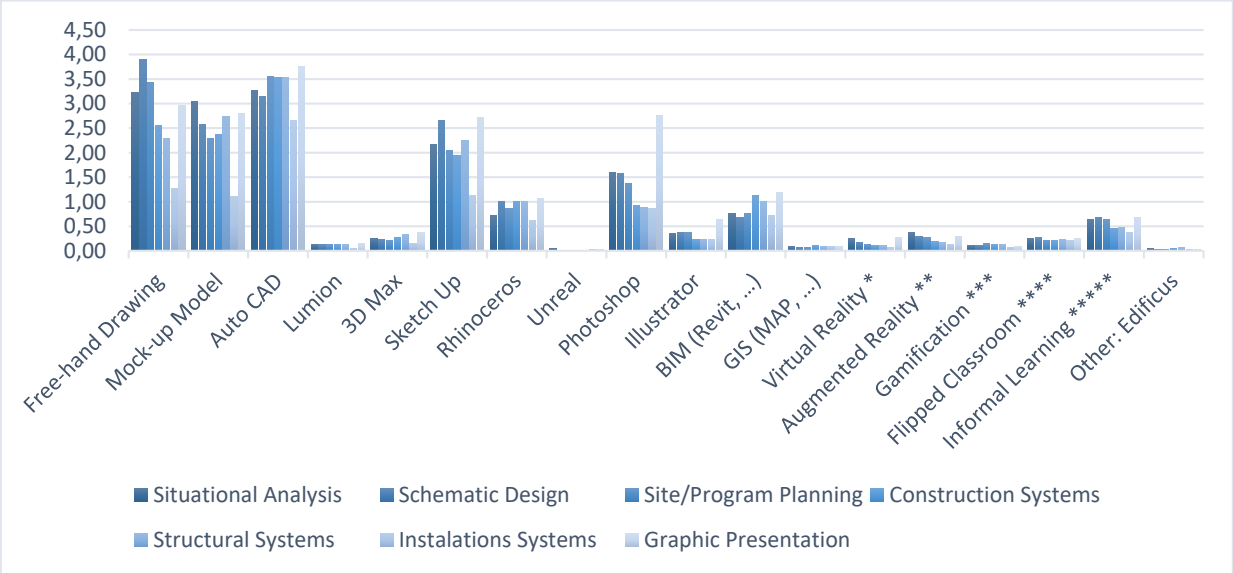

Figure 27: Use of the different systems in the different phases of the project design, UPC

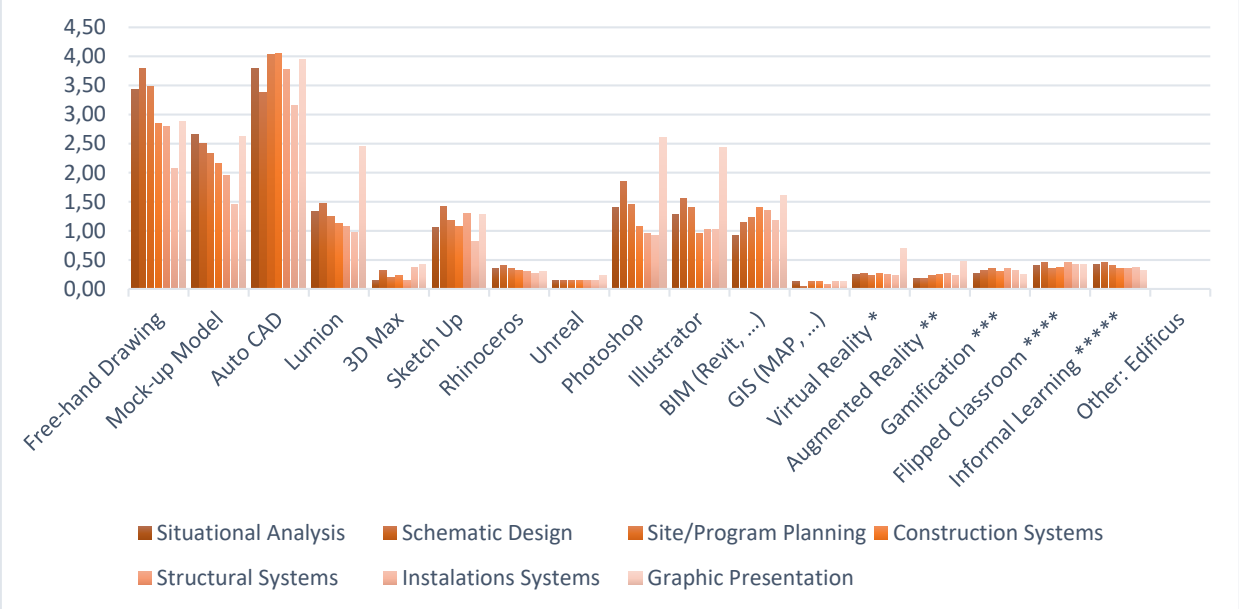

Figure 28: Use of the different systems in the different phases of the project design, URL

Figures 28 and Figure 29 show a diagram of the use of different systems in the different facets of the design of a project. For these results and the ones gather from 4th year-students, plus a post-test made, conclusion and deductions are still in the process of analysis for all the collected data. A comparison of the level of knowledge will be grouped in software typology (3D modeling, parametric, real-time rendering, virtual reality, etc.) to evaluate the method more than the software itself.

5.2 Future lines of research

Future lines of research will focus on the main digital strategies used in architectural and urban education, and to establish a current relationship with the motivation and utility perceived by professors and students of interactive virtual strategies for the understanding and comprehension of complex 3D environments. The educational design for implementing new virtual strategies in architecture teaching needs the collaboration between the faculty, the professors and the students, addressing projects and using free or educational applications that could improve the quality of traditional deliveries. Figure 29 shows multiple systems that we can apply in the educational context for understanding the main concepts of urban contents.

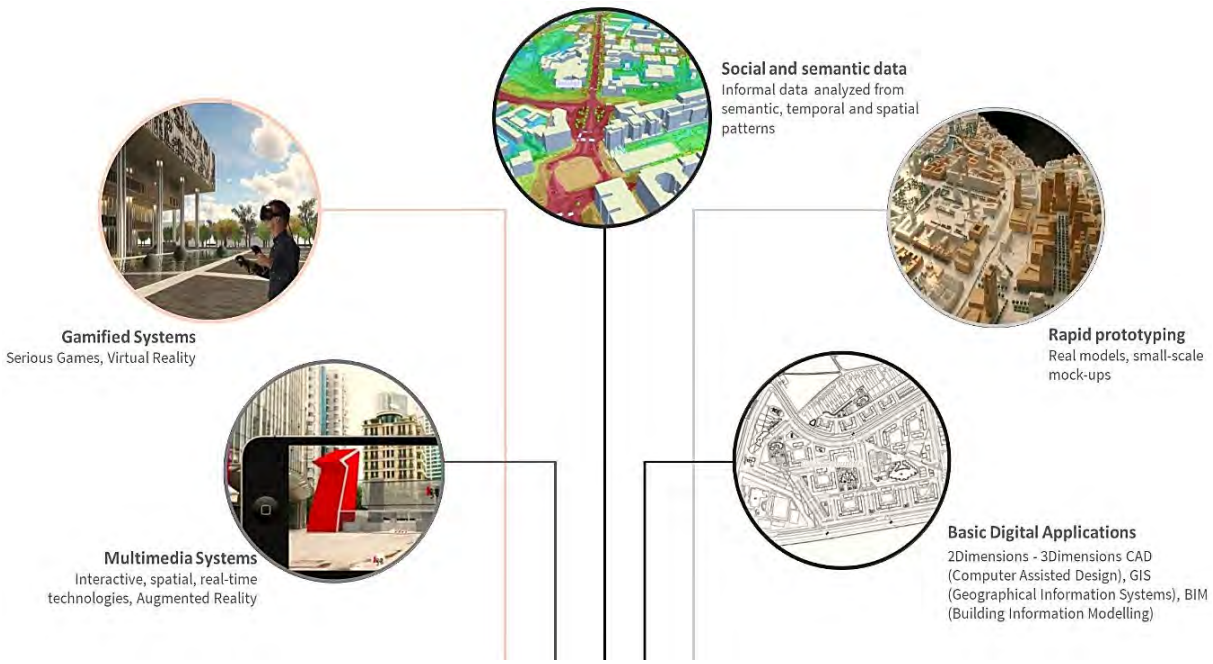

Figure 29 Examples of technologies used for the visualization of the 3D space.

Following the lines of the thesis and the conclusions is necessary to know which methods and tools students are currently using, its limitations and the potential to be accompanied by other ICTs. The following are the lines that we will continue:

- Continuous improvement of teaching methods that include new visualization technologies applied to the urban design representation.
- The analysis of the basic and specific competences, as well as the acquisition of representation and content generation skills, will be studied as objectives from a technological approach.
- Exploration of technological innovation in VR as tools to project, analyze and interpret the urban space from the advanced visualization combining interaction systems with the contents.
- Verification of the applicability of projects from the academic field to professional working with users in the development phases, from the integration of usability studies and user experience.
- Immersion in digital workspaces for collaborative project development or generation of the form from visual interaction with virtual systems.

It is planned to participate in the next international research projects from the GRETEL group on Campus La Salle Barcelona, Ramon Llull University.

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7 Related publications

The results of the research work have been published in articles, and journals, as well as papers in national and international scientific conferences. The following section is a sample of the articles collected that contribute to the development of the investigation initiated in the context of the university education in Architecture. The reading of the different articles shows the natural sequence in the orientation of the work.

The collaboration with the project supported by the National Program of Research, Development and Innovation aimed to the Society Challenges was key in the investigation. The order of the articles is linked with the development of the research and its lines (explained in section *1.5 Research Structure*, Figure 2). The most important articles and the direct relationship with the research path are detailed below:

Teaching and learning urbanism in architectural schools

Mónica V. Sánchez-Sepúlveda, Jordi Franquesa, David Fonseca, The IAFOR International Conference on the City. July 13-15, 2018 Barcelona, Spain. pp. 23-27, ISSN: 2432-4264, Official conference proceedings FEARFUL FUTURES. Cities in the twenty-first century. Cultural studies and the question of agency in the twenty-first century. IAFOR Scholarship Award

Introducing a new ICT tool in an active learning environment course: performance consequences depending on the introduction design

José Antonio Ferrándiz, Fernando del Ama Gonzalo, Mónica Sánchez-Sepúlveda, David Fonseca, International Journal of Engineering Education. ISSN: 0949-149X. Published 2019, Vol. 35, No.1B, pp.360-371. JCR Q4, SJR Q1.

Programming virtual interactions for gamified educational proposes of urban spaces

Xavier Calvo, David Fonseca, Mónica Sánchez-Sepúlveda, Daniel Amo, Josep Llorca, Ernest Redondo, HCI-International 2018 - Zaphiris P., Ioannou A. (eds) Learning and Collaboration Technologies. Learning and Teaching. LCT 2018. Lecture Notes in Computer Science, vol 10925. Springer, Cham. July 15-20, 2018 Las Vegas, Nevada, USA, pp.128-140, Print-ISBN: 978-3-319-91151-9, Online-ISBN: 978-3-319-91152-6, DOI: 10.1007/978-3-319-91152-6_10

Qualitative assessment of urban virtual interactive environments for educational proposals

Xavier Calvo, Mónica Sánchez-Sepúlveda, David Fonseca, Nick Van der Graaf, Miquel Sans, Marc Gené, Isidro Navarro, Sergi Villagrasa, Ernesto Redondo, TEEM2018 - 6th Technological Ecosystems for Enhancing Multiculturality. Ed. Francisco José García-Peñalvo, University of Salamanca. October 24-26, 2018 Salamanca, Spain, pp.716-722, ISBN: 978-1-4503-6518-5. DOI: 10.1145/3284179.3284295

Innovation in Urban Design Education

Monica Sanchez-Sepulveda, David Fonseca, Xavier Calvo, Isidro Navarro, Jordi Franquesa, Ernesto Redondo, Marc Gené, TEEM2018 - 6th Technological Ecosystems for Enhancing Multiculturality. Ed. Francisco José García-Peñalvo, University of Salamanca. October 24-26, 2018 Salamanca, Spain. pp.729-736, ISBN: 978-1-4503-6518-5, DOI: 10.1145/3284179.3286731.

Collaborative Design of Urban Spaces Uses: From the Citizen Idea to the Educational Virtual Development

Monica V. Sanchez-Sepulveda; David Fonseca; Jordi Franquesa; Ernesto Redondo; Fernando Moreira; Sergi Villagrasa; Enric Peña; Nuria Martí; Xavier Canaleta; José Antonio Montero, Masaaki Kurosu (eds) Human-Computer Interaction. Design Practice in Contemporary Societies - Thematic Area. Held as Part of the 21st HCI International Conference, HCII 2019. Proceedings, Part III. Lecture Notes in Computer Science 11568, Springer 2019, ISBN 978-3-030-22635-0 Online ISBN: 978-3-030-22636-7, pp. 253-269, June 27, 2019 Orlando, FL, USA.

Visual Technologies for Urban Design Competences in Architecture Education

Mónica V. Sánchez-Sepúlveda; Nuria Marti-Audi; David Fonseca, In Proceedings of TEEM 2019. TEEM'19 - Technological Ecosystems for Enhancing Multiculturality, October 16-18, 2019, León, Spain, pp. 726-731, ISBN: 978-1-4503-7191-9/19/10. DOI: 10.1145/3362789.3362822. Best Paper in Education Innovation Award

Virtual Urbanism: A User-Centered Approach

Mónica Vanesa Sánchez-Sepúlveda; David Fonseca; Jordi Franquesa-Sánchez; Nuria Martí-Audí, In XIII CTV 2019 Proceedings: XIII International Conference on Virtual City and Territory: “Challenges and paradigms of the contemporary city”: UPC, Barcelona, October 2-4, 2019. Barcelona: CPSV, 2019, p. 8430. E-ISSN 2604-6512. DOI: http://dx.doi.org/10.5821/ctv.8430

Aquesta Tesi Doctoral ha estat defensada el dia ____ d_____ de 20___

al Centre_____

de la Universitat Ramon Llull, davant el Tribunal format pels Doctors i Doctores sotasignants, havent obtingut la qualificació:

President/a

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Vocal

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Vocal *

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Secretari/ària

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Doctorand/a

(*): Només en el cas de tenir un tribunal de 5 membres