New Lighting Representation Methodologies for Enhanced Learning in Architecture Degree

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Abstract. Lighting conditions adjustment is one of the most difficult tasks in architecture visualization. This paper presents a new teaching methodology in the field of lighting representation for enhanced learning with students of architecture degree. It aims to assess how lighting balance competences are acquired in undergraduate and master's courses in architecture, urbanism and building technologies. The working hypothesis is that this new learning process will contribute to a better understanding and mastery of lighting control in architectural rendering scenes. It is based on comparing different widely used technologies such as building information modelling, virtual reality, augmented reality, photorealistic rendering software and game engines. The implementation will be evaluated including user experience analysis all along the process with quantitative and qualitative surveys. The research will try to demonstrate how this method can improve student's skills, especially in realistic lighting representation of projects of the subjects related to digital and graphic representation. The subjects will be from several courses: Architecture Representation II from second course, Architectural Representation III from third course, Multimedia and Techniques of Modelling and Digital Production Oriented to the Development of Constructive Solutions from fourth and postgraduate course respectively. This research will also address the issue of how students can implement their new acquired skills to other subjects of the Degree of Architecture at the School of Architecture of the Polytechnic University of Barcelona.

Keywords: Architecture · Enhanced learning · Lighting · Virtual reality

1 Introduction and State of the Art

One of the most difficult tasks in architectural rendering is the Lighting settings adjustment. Most of the times final images are presented with false exposure and camera parameters in order to make them more attractive. In this cases lighting balance is automatically generated and this compensation may not be used in real environments

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especially indoor and in night scenes. In contrast, final renders in professional lighting software widely used for calculate number and type of lights, are usually represented using light intensity isolines and numerical parameters. These non-realistic images are inadequate resources to enable decision-making based thereon.

The study of artificial lighting conditions of buildings is a topic that has been applied for some time in the field of education of future engineers. [1–3] but it's a very rare event in the training of architects, except in those countries where the degree in Architecture is a long educational cycle. Students are then hardly trained in lighting variables as colour temperature, intensity, camera exposure parameters, etc. but once they try to replicate this parameters to their real projects, space perception completely changes.

In particular, that competence is usually addressed by other technicians involved in the field of construction [4]. It's often approached from a professional perspective, especially on studies of indoor environments [5] or daylight conditions [6–8]. This could be due to the more creative and visual profile of architects and interior designers. Now, in any case it is not addressed in the field of urban design, except lighting calculations of certain urbanization projects, in which case, the perceptual aspects are not taken into account. Our proposal aims to assess how these competences are acquired in several undergraduate and master's courses in architecture, urbanism and building technologies, either in buildings design, public spaces and urban areas, as they are understood in Spain.

2 Methodology

The research will take place in two periods of the degree of Architecture. The duration of the degree is six years, students finish their studies developing the final degree project at the last year. At the first period the assessed subjects are focused on lighting calculation and analysis to obtain visual and data results. In a second phase, the subjects improve the communication capabilities of the students for realistic images representation. At the same time, the students are attending other subjects where this practices will impact.

The proposal stars with an approximation to the representation of the daylight and shadows at the subject Architectural Representation II from second course of the degree. Traditionally, this process of representation was developed with Computer Aided Design software, but these methodologies are moving to Building Information System software. The results of the first approach to light representation is possible with the visualization tools provided by this software. The research will include virtual reality methodologies to expand the perception of lighting and shadows of the projects and will analyse the results of the VR implementation and the impact at the subject Projects II from second course.

The second field of study is the photorealistic representation of the projects and it is developed at the third course of the degree at the subject Architectural Representation III. Lighting and materials mapping are the main topics in order to get the most accurate render images. The tools used for this purpose are 3D modelling software and several render engines software. The research will include the data analyse of illumination based on calculation software of indoor/outdoor lighting and also the approach between both methods for the final project design.

After the second and third courses, the students are able to represent their projects with photorealistic images and graphic documentation where lighting provides visual and data results. Next steps will be focused on the communication phase of the projects, it means, the way how the students show the concepts, processes and final results of their projects.

At fourth course the subject Multimedia is centred into immersive representation with an approximation to videogame engines to create virtual reality and augmented reality presentations. The research is focused on the analysis of the learning process of these tools in the field of architecture visualization. However, this implementation requires mechanisms of optimization of lighting for a better performance of the experiences, and this becomes the focus of the methodologies to explore.

The last field of work will be the development of the final degree's project with technical documentation and presentations in photorealistic images and videos, and the subject is Techniques of Modelling and Digital Production Oriented to the Development of Constructive Solutions from postgraduate course. The practices include parametric and real-time rendering software. The impact of the results of this work will be explored during the development of the final degree's project.

2.1 Assessment

The experience is based on the hypothesis that the new tools of information and communication technologies (ICT) such as immersive Virtual reality, when they're used in an e-learning environment, can help to improve students learning processes. It increases their motivation and competences with a reduction of time and it's a cost-effective solution (we'll use for that free applications or educational licenses).

In a first phase we will study how the subject will be presented in the basic courses of the BIM Architecture degree and Architectural Representation applied to Urban Design. In a second level, it will be evaluated if the competences are undertaken in master courses and in Architecture and Building Engineering final works. Finally, highest competences acquirement in the design and calculation of artificial lighting systems will be evaluated in the master of Architecture, Urbanism and Building Technologies. Assessment will be carried out both for indoor environments and public and urban space. In adition interactive and realistic visualization strategies for their final adjustment will be conducted. The ultimate goal is the evaluation through analytical learning, if students assume such competencies combining scientific reasoning with visual education, intuition and creativity.

2.2 Phases

Research Design Process. This section is the first of the research process, understood as the one that will be carried out with a group of students with a similar profile. This group of students will define the control group of each subject and it will be the one in which the VR will be introduced for the study of lighting. The improvement of their skills will be compared with that of another group of students who use traditional methodologies. As previous studies in urban projects for education [9–11], the analysis of the data obtained in the pre-test, post-test surveys and bipolar laddering tests will allow us to evaluate the improvement through the learning analytics techniques [12–15]. This research evaluates subjective aspects of the perception of comfort and light safety of an exterior or interior architectural environment. For this reason, the tests will introduce a qualitative assessment as a complement to the quantitative one, which is understood as a method mixed.

The teaching experiment will be repeated in various courses of the degree and master, either in the design of interior environments such as public space and urban design [16–19]. That data will be available in various phases of the training of future architects, urban planners and building engineers, as it's demonstrated in previous projects for digital urban transformation [20, 21]. This process will evaluate then if the competencies improvements vary according to the previous preparation or are equivalent indistinctly, due to the use of the immersive VR.

Project Based Learning. The development of the contents will have a sequence of steps depending on the structure and academic contents of each of the courses of the implementation. For example, in the subject Architectural Representation III of the third course, the first step will be the generation of a first 3D digital model with a specialized software (Fig. 1), then the ambient lighting will be added, and subsequently it will lead to a 3d digital model that will be visualized with VR HMD. After this immersive experience, a readjustment is made using again photometric lights. The scene lighting is then rendered to textures and projected onto the surfaces, greatly improving both the performance of the simulation and the realism and faithfulness to the lighting conditions that would occur in reality (Fig. 2), the result will be a final design of the architectural or urban environment (Fig. 3).

Fig. 1. Testing the lightning evaluation in indoor projects with free specialized software.

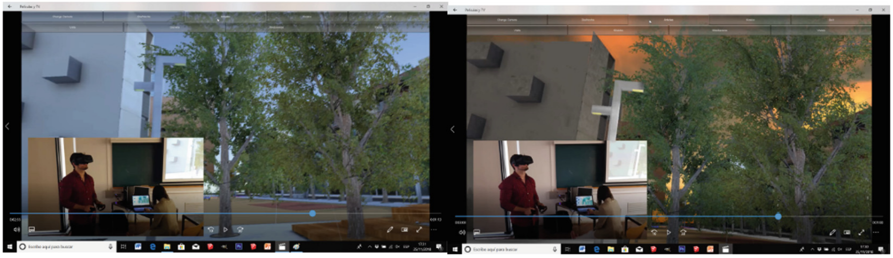

Fig. 2. Students testing parameters of the urban project lightning with a Virtual Reality HMD.

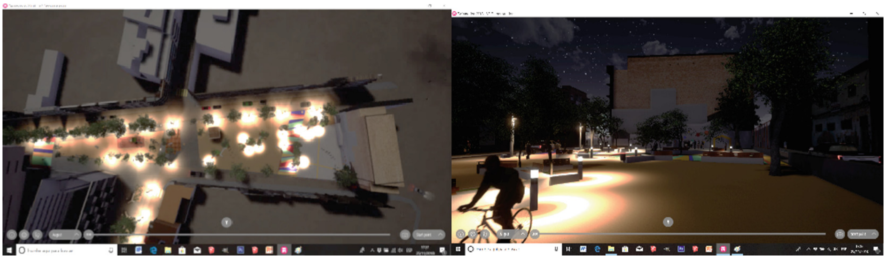

Fig. 3. Creating VR scenarios for testing lightning and visual analysis.

3 Conclusions

We intend to demonstrate the lack of background in the design of architectural lighting models taking into account the perceptive aspects as a complement to the calculations. It is necessary to incorporate perceptive and subjective factors in architecture studies. It is convenient to introduce elements of environment as the vegetation in the designs in the external environments. A real analysis of the materials in interior environments is required as key factors to generate comfortable designs that offer security. It is necessary to generate realistic virtual scenarios and immersive visualization with virtual reality HMDs (Head Mounted Displays) for an optimal understanding and perception of the projects. This experience will allow students to travel freely and consequently assume an integral design of the environments. It is a priority to introduce highly efficient and agile teaching processes, which allow to go from the initial designs with reliable calculation bases to fully controlled final designs, in a very short time rapidly increasing the students' skills, following validated previous works [22, 23].

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