Education Technologies in Architecture and Urbanism

The potential of virtual and augmented reality

Roberta Betania Ferreira Squaiella
University of Architecture and Urbanism
Universidade Presbiteriana Mackenzie (UPM)
São Paulo – Brazil
robssquaiella@gmail.com

Roberto Righi
University of Architecture and Urbanism
Universidade Presbiteriana Mackenzie (UPM)
São Paulo – Brazil
roberto.righi@mackenzie.br

Maria Victoria Marchelli
University of Architecture
University of Florida, CityLab Orlando
Orlando, Flórida – United States
mv.marchelli@ufl.edu

***Abstract*—This article presents a reflection on the potential of use of virtual reality and increased resources for higher education, highlighting architecture and urbanism education. Based on literature review, presents short historical development of virtual and augmented reality, and some experiments in architecture and city planning courses are pointed out. Relying on the neuroscience studies, it is believed in the importance of sensory stimulation for activation of synapses that encourage the acquisition of a significant learning.**

Keywords—Virtual and augmented reality; Significant learning; Architecture and urbanism.

I. INTRODUCTION

Use of virtual reality and augmented reality resources is recent in the field of education. According to the concepts of neuroscience, which studies the nervous system and its functions, researchers have been tried to understand how learning takes place in the brain, and how stimulating the various senses can favor a significant acquisition of new knowledge.

According to French thinker Michel Serres, there is currently a third world revolution taking place in communication. The first one was the transition from oral communication to writing; the second one, from writing to printed-paper; and the third one, from printed-paper to the virtual environment. Because of this transformation, Serres believes that a new intelligence profile is being built, quicker and more multiple and intuitive [1].

The advances of information and communication technologies and their wide acceptance by society are bringing about transformations in the perception of daily life and can be seen as a huge potential for college-level education. According to Spanish sociologist Manuel Castells, “Internet is the infrastructure of our lives” and, due to its massive use, we are already living a real "virtuality" rather than a virtual reality [2].

To reference [3], virtual simulators serve to test situations with all imaginable variations, predicting consequences from a hypothesis, exploring complex systems, leveraged by virtual reality. Thus, it is understood that augmented reality and virtual reality must be potential tools to enable learning experiences that, if present in a certain context, will promote an exploration of real-life data in virtual environments and simulations [4].

To reference [5] have asserted that man has been seeking over the years to master technologies in order to make his life easier. The computer, first used as a war resource, has gone through evolutions that allowed for its reduced size and higher efficiency, as it was gradually inserted in institutions and even households until it became an educational tool, as a teaching resource in the education and learning process.

The quick advances of technology, particularly for mobile devices, have deeply affected education, though the latter slowly transforms and keeps attached to defined places and times, such as schools, classrooms, the school calendar, etc. It is necessary to keep the students' motivation so that they can involve in participative and affective processes [6].

The contemporary student, who is in constant contact with computerized devices, needs stimuli that can favor learning. Virtual reality and augmented reality resources are understood to cause positive excitations for obtaining new knowledge, which is assimilated and comprehended by the student rather than just memorized. According to reference [7], one of the discoveries of neurosciences is that, through delightful and challenging activities, the synapses between neural cells get stronger and the neural networks take place more easily, thus providing effective learning.

II. Brief History of Virtual Reality and Augmented Reality

The virtual reality began in the industry of flight simulators, employed by the U.S. air force right after the World War II [8]. To reference [9], the beginning of virtual reality relates to cutting-edge computer technology, and he highlights that, in the early 1950s, filmmaker Morton Heilig designed the first device, called Sensorama, that combined in a cabin the three-dimension film and the other resources such as stereo sound, mechanical vibrations, scents, and ventilator-produced air. He sought, through that cabin, to achieve all human senses by means of a simulation of a motorcycle ride through New York city, where the user was given for instance a wind sensation promoted by ventilators, as well as the rigidity of the path, due to the seat-installed vibration system.

In the late 1960s, engineer Ivan Sutherland built the first virtual reality helmet, the precursor to a number of research works and developments. In 1984, William Gibson defined in his science fiction novel called Neuromancer the term cyberspace to designate a graphic representation of data abstracted from the databases of all computers [8].

Gibson described a universal computer network containing all sorts of information, where you could "enter" and explore data in a multisensory manner and where people with implants in their bodies could directly transmit information to the computer [8]. Thus, cyberspace is understood as an imaginary space where a simulation is controlled by the virtual reality interface.

It was during the 1980s that Jaron Lanier, a professional in the field of computer sciences, proposed the term virtual reality (VR), in attempt to combine the real and the virtual [9]. To reference [8], Jaron Lanier created this term to differentiate between computer-made simulations and simulations involving several users in a shared environment.

The virtual reality is not limited to computing professionals, even though it does work with scientific and technology development in search of interactive interfaces that can come closer to human senses. Virtual reality (VR) is an interface that allows the user to access computer-run applications and interact in real time with three-dimensional elements by viewing and moving. Thus, a user's experience can be enriched through stimulation of the other senses such as their touch and hearing [9].

The term VR is quite comprehensive, with different interpretations among scholars, software developers, and researchers. In a simplified manner, VR is understood as an interface simulating a real environment and allowing for interaction among participants. Through VR, you can create three-dimensional environments, including interactive objects, which simulate the sensation of presence in a real environment [8].

The reference [8] further stress that virtual reality is widely confused with animation, with CAD (Computer Aided Design), or with multimedia, though it has the following differences from these two: it is oriented to the observer in the virtual scene; it offers a sensation of presence in the virtual world; it allows for the user's interaction with the action viewed; it is handled in a more intuitive manner, with little or no difficulty to operate the computer interfaces; and the process of transforming the models into images takes place in real time.

With the massive evolution in computing, which enabled higher efficiency in computers, it was possible to integrate videos and interactive virtual environments through the advances of multimedia and virtual reality resources. This progress has worked for the benefit of augmented reality (AR), which can complement the real environment with virtual objects, using applications on sophisticated or popular platforms [9].

The difference between virtual reality and augmented reality lies in the fact that the first one carries the user to the virtual environment, whereas the second one keeps the user in their physical environment and carries the virtual environment into the user's space. Augmented reality allows for an interaction with the virtual world in a more intuitive manner, with no need for training or adaptation [9].

III. Virtual Reality

Before virtual reality was developed, the ways of portraying what is imaginary were either to describe it orally or to represent it, when possible, through resources that are imposed cost, production, or interaction limitations, as is the case with drawings, sculptures, scale models, movies, and animations [9].

With the development of computer resources, it was possible to converge all communication technologies for computers and exceed the barriers of the monitor screen to create interactive three-dimensional environments in real time, through virtual reality [9]. Thus, a representation of what is real, of immersion, and the interaction with what is imaginary have become easier to be attained.

Use of high-speed Internet has made it possible to access the means of communication, which integrate in a medium convergence and enable immersion into three-dimensional realities. To reference [10], virtual reality can be explored with full knowledge experiences that mark all senses, offering opportunities for higher and better exploration than the concrete spaces to which they refer, according to the conditions developed. It should be stressed, as specific programs are developed, registration, follow-up, and interaction with other means and other people are made possible.

Development of a virtual environment allows people's senses to be widened in intensity, in time, and in space. That way, you can see, hear, feel, act, and travel far beyond human capacities. For learning, virtual reality can be used so that students will visit classrooms and laboratories in virtual universities, as well as interact with professors and classmates to conduct scientific experiments. Since they can enter the virtual base and handle the virtual assistance terminal, in a similar manner to the real equipment, or talk to the virtual manager, represented in the environment by an avatar [9].

The programs developed for creating virtual reality environments enable modeling of virtual equipment and simulate its real behavior. Such simulations allow for savings

with costs and the development cycles, validating virtual products that have been virtually tested. It is further worth stressing that the technology advances allow for better equipment development, such as gloves and glasses, and consequently increase the amount of users and applications [8].

The reference [11] reported the experience conducted at the Federal University of Pará, when virtual reality was employed to support lessons about the history of the city of Belém do Pará in the 19th century. With the creation of a virtual environment, an avatar (virtual character), wearing clothing from that time, runs through the city for the purpose of locating and obtaining information on the various important buildings for the city of Belém's history. This experience points toward the potential creation of educational games to support the students' active learning.

IV. Augmented Reality

Augmented reality (AR) consists in introducing virtual objects into a real environment by means of synchronous interactions, in three dimensions. Which can take place on a video or through screen projections with technological glasses, such as Google Glass, for instance, which are electronic glasses, with a small screen, above the field of view, that allows the user to navigate through Internet resources.

According to reference [4], AR is a resource that is already available for decades now, but it ceased to be regarded as a simple gadget and has become a tool of great potential, as it allows the levels of information on the three-dimensional space to produce new world experiences, sometimes referred to as "mixed reality". These experiences bring about new expectations as to information access and enable new learning opportunities, due to the ability to respond to the user's stimulation. This confers upon it a huge potential for learning and assessment, as it allows students to build new understandings on the content, based on the interactions with virtual objects, which bring them implicit knowledge.

The benefit provided by AR of introducing into the student's personal space a way to easily handle and understand the dynamic processes, the extensive data sets, and the very large or very small objects. For that purpose, a big tendency exists for a migration from desktop computing to mobile devices such as, for instance, the glasses, tablets, and smartphones [4].

Through augmented reality (AR), the user can portray and interact with imaginary situations, involving virtual objects, which enable real-life environments to be reproduced with the support of technological apparatus. As an example, you can virtually insert the decoration elements in an empty (real) apartment with virtual furniture [9].

We can mention, as a hands-on use of this resource for architecture and urban planning learning, the experiments conducted by the GEGRADI group (Digital Graphic Education-Learning Studies group), from the Federal University if Pelotas. According to reference [12], employed an exercise of viewing cross-sections in curved shapes, with aims to widen the means of representation in architecture. It was observed that, through this activity, interactive and instantaneous handling and transformation of objects by using AR can supplement the digital technology practices and promote further comprehension on geometric elements [12].

Another example of an augmented reality application, also conducted by the Federal University of Pelotas, was adding the informational potential to the graphic pieces produced for the cards of the historical city of Pelotas, for the purpose of widening the level of interaction and enabling another viewing method based on three-dimension digital content. The study conducted allowed a specific application to be created for viewing the architectural historical heritage in augmented reality. The academic community having interest in this topic, indicating the potentials of augmented reality for teaching historical architecture, may significantly add the result of this experiment with the research actions [13].

V. Neuroscience and Education

At the Educação 360° event, held in Rio de Janeiro in September 2015, the potentiality of the virtual reality for education was approached, it being understood that, for neuroscience, the act of living the scenarios by means of virtual reality boosts education, as the brain understands the scene as if it was actually experienced. The contents correctly produced in a joint creation with educational centers can be timeless [14].

One of the fields of neuroscience, which is the scientific study of the nervous system, seeks to understand how learning works. It is necessary to previously understand how the human being learns so that we can offer stimuli contributing toward their cognitive development [5]. It is worth mentioning that the brain is responsible for learning and that each student has an individual way of learning.

The neuroscience is still a young science, approximately 160 years old, which has had its peak achievements following the 1990s and has been causing significant changes in our way of perceiving brain functioning. The contributions from this science have aroused interest in several segments, education included, which seeks to learn how learning is processed in each individual, so that improvements can be made in the educational perspectives [15]. Great complexity is deemed to exist in the act of learning, which entails, among other issues, emotion, interaction, and motivation.

The external stimuli that are captured by the sensorial channels relate to the forms of learning, as they are received as information (sound, vision, touch, taste, olfaction) in specific brain areas, in charge of preparing, decoding, and associating that information. When activating these brain areas, we can promote memories and significant learning [16].

The imaging experiences of contemporary society, in constant contact with computers, tablets, and smartphones, makes the student feel unmotivated when they arrive at school and face an education method based on class books, notebooks, and blackboard. When living experiences that come closer to their learning expectations, handling an electronic device, the student receives positive stimuli for acquiring new knowledge, which can increase the possibilities of learning [5].

To briefly understand how information is processed in the brain, we find that there is a network of neurons that process and convey information by means of nervous impulses. In the bonds between neurons where the information pass through, a synapse takes place, which regulates the transmission of information in the nervous system. Such regulation is performed by releasing neurotransmitters that can stimulate or inhibit other impulses. The stronger the stimulation from the environment, the higher the ability to learn will be [17].

Using proper strategies in a dynamic and delightful learning process causes changes in the amount and quality of synaptic connections, which play an important role in learning and reach cerebral functioning in a permanent and positive way. This author highlights that the studies in the field of neuroscience clarify that learning takes place when two or more sensitive systems work in an interrelated manner [7]. Thus, the importance of conducting activities to simultaneously stimulate more than one sensitive system should be highlighted, such as, for instance, games and augmented and virtual reality resources, which stimulate logic reasoning, attention, and concentration in a challenging and delightful way for students.

Virtual and augmented reality are believed to have a potentiality for learning, since such resources enable a more dynamic interaction, able to stimulate the various senses. The interaction behaviors with environment, throughout life, will result in the learning process [18]. Thus, learning is a characteristic intrinsic to man. Learning depends on the brain and requires several mental functions such as attention, memory, perception, emotion, executive function, and others. Pedagogic strategies must use resources that are multisensory in order to activate multiple neural networks that will establish an association with each other [18].

VI. The Potentiality of Augmented and Virtual Reality for Architecture and Urban Planning Education

The virtual space is designed by means of architectural methods, along with memory development and strengthening [19]. That way, the memorization process becomes key to building the virtual context, where the visual and information materials, explored by the digital technology development, enable us to review mind exploration methods. Virtual reality boosts the spatial memorization systems, since it enables the user to have an illusion of telepresence and immersion, which can be compared to architectural construction in the concrete world.

An architect and urban planner is a professional directly focused on visual arts, since, for an understanding on their design, drawing plays a vital role. When representing the architectural project for clients or for building it at the construction site, two-dimensional drawings are often resorted to, which do not fully cover the proposed spatiality, thus requiring the professional's ability to manage to clearly expose their design [20]. Design representation has always been limited to the instruments available and undergone evolutions in the digital era, however such instruments are still more widely used for graphic representation than for understanding the project as a whole, in such a way that might provide a virtual experience and explore the various senses.

Even though computing resources are widely used by architecture firms, virtual and augmented reality resources, which can change the way of producing and viewing projects, should be better explored in architecture and urban planning education. Such resources enable the project to be viewed in such a way that is closer to the object to be built. Through simulations and analyses, we can think of new ways of building, considering climate changes, population densities, as well as other problems and variables of these days [20].

VII. Considerations

With the development of contemporary technologies, society is present in the imaging world, where media resources, incorporated into computerized equipment, give us opportunities and stimuli to more easily understand contents and make significant learning more delightful.

Virtual and augmented reality resources, employed on a large scale by the entertainment industries, might be converted into interactive education, allowing the student to interact with sounds and images, thus broadening the learning methods. Supporting ourselves on the neuroscience and education studies, we can understand that, when more than one sense is simultaneously stimulated, effective learning is boosted.

That way, we understand that virtual reality and augmented reality resources enable the student to actively interact with knowledge building, by interpreting reality, being able to simultaneously explore their senses, such as hearing, sight, and touch. Incorporating these resources into education gets students closer to their reality outside the educational environment, thus offering the required stimulation for significant learning.

Incorporating augmented and virtual reality resources into the architecture and urban planning education does not mean to exclude the traditional methods for design representation, but rather to supplement the representation with some architectural spatiality that provide students with an effective meaning. It should also be stressed that these resources might be introduced not only into design-related subjects, but also into theoretical subjects, and are able to help, for instance, comprehension on historical factors.

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