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EMBEDDING VIRTUAL REALITY IN ARCHITECTURAL PEDAGOGY: INSTRUCTIONISM VERSUS CONSTRUCTIONISM APPROACH

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EMBEDDING VIRTUAL REALITY IN ARCHITECTURAL PEDAGOGY: INSTRUCTIONISM VERSUS CONSTRUCTIONISM APPROACH

Abstract

As more related to the typology of architectural pedagogy, Instructionism and Constructionism theories are used to make more advancement in this domain. They are concerned with the role of both instructor and learner within the outline of a well structured pedagogical framework (education system). However, the developments in information technology and its imprints on all life aspects have profoundly influenced this system. Architecture pedagogy -as in many other domains- is now radically affected by information technology (IT) developments. Virtual reality is one of the leading applications of IT in architecture.

This paper is concerned with embedding virtual reality in architectural pedagogy. It investigates the approach to use this technology best within an understanding of Instructionism and Constructionism theories. It proposes a framework to highlight the role of virtual reality technology in these regards. In its last part, this paper interprets the findings of questionnaire results from students of the Faculty of Architecture, Design, and Built Environment at Beirut Arab University (BAU) to validate its proposed framework. The application shows the positive impacts of using virtual reality as a compulsive force to keep 'Instructionism'/ 'Constructivism' vicious circle. This would be of great potential for architecture students to get more in-depth experiences.

Keywords

Architecture Pedagogy, Virtual Realty, Instructionism, Constructionsm, Beirut Arab University (BAU)

1. INTRODUCTION

Architecture pedagogy has always been a debatable matter. The second half of the 20th century witnessed several pedagogical experiences that profoundly influenced the architectural domain. According to Colomina et al. (2012), the continuous examination of the well-settled platforms in architectural pedagogy is the major force for pushing the domain ahead. This could be clearly seen as linked to the mass, rapped, and drastic changes in all life aspects during the last few years. In view of that, three main domains are the major fields of these transformations: socio-political, cultural, and technological (Colomina et al. 2012).

According to Reigeluth, (2012), the reflection of these transformations is interpreted within broad understandings of the shift from industrial to post-industrial paradigm. As he asserts, the responsibility for the education product is the 'System' rather than neither the instructor nor the learner. The education and training industrial system met the needs of that time. Its aim was to 'sort' students according to their capabilities to either manual-oriented labor or managers/professionals. Meanwhile, post-industrial education is supposed to be a system that is designed and continuously developed to maximize learning capacity.

This shift in the education 'system' is based on a redefinition of education typology as moving along all Behaviorism, Cognitivism, Constructivism, Constructionism, and finally Instructionism theories of education (Schuman, 1996). While 'Behaviorism' focuses on behavioral patterns repeated to be automatically embedded in the learner's behavior, 'Cognitivism' adds another dimension, as it links between changes in behavior on one side and the cumulative cognitive the learner has gained. In a similar analogy to Maslow's pyramid of needs, these two perspectives shape the foundation and prerequisites for the other theories. 'Constructivism' is based on a postmodern vision of the education system. It rejects the grand theory; as each learner constructs his/her own vision based on his/her unique experiences. However, it prepares the learner to face unpredictable situations based on the fact of continuously increasing complexity (Smith, 2003).

As more appropriate to the architectural domain, Hein (1991) advocates for 'Constructionst' approach. It is based on a premise that each learner individually (and socially) constructs knowledge and meanings for his/herself as they are learning. Actually, two basic understandings are shaping this approach. The first is the focus that has to be oriented towards learner thinking about learning not to the taught subjects itself. The second is the importance of meaning associated with the learner 'Constructed' experiences as the main source of knowledge. Based on a more comprehensive methodology; Reigeluth (1999) advocates for the 'Instructional Design Approach'. It is defined as one that "describes specific events outside the learner that facilitate learning" (p. 13). He shows the relationship between 'constructionism' and 'Instructionism' theories as the latter involves learners' control as they are taking an important role in their learning. They decide what to investigate and determine their learning aim, objectives, and goals. In this regard, the instructor's role is to facilitate learners' capabilities to discover and develop their knowledge. So, it is seen that 'Instructionism' offers a more broad vision to architectural pedagogy, as it shows the way to instruct learners to construct their own knowledge and vision (Reigeluth, 2012). In more in-depth investigations, Ryder, (2003) argues for an 'instructional design model' that helps future designers to formulate a "semblance of conscious understanding", as it facilitates visualizing the problem and breaking it down into handy items.

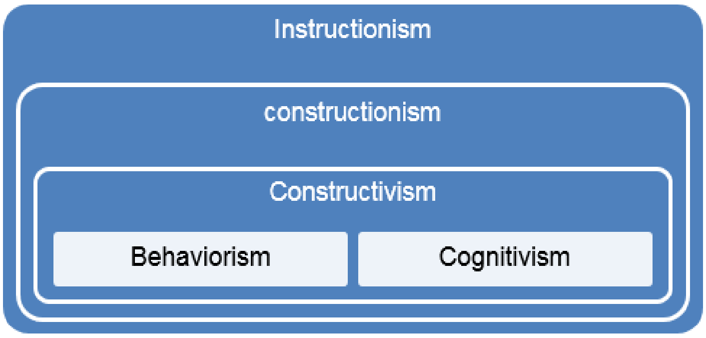

Fig.1: Theories of architectural pedagogy. (Reference: The Authors)

This paper presents an overview of the interrelationship between Instructionism and Constructivism theories of architectural pedagogy (Figure 1). It reviews the literature to build an argument about embedding virtual reality (VR) in architecture based on these two theories. Then it uses the concluded understandings to develop a model that gives insights into the way (VR) could be introduced. The last part of the paper goes through an experiment performed in the Faculty of Architecture, Design, and Built Environment at Beirut Arab University (BAU) to show the validity of the proposed framework. Students were asked about their experience in using virtual reality in their course tasks. Their responses were classified according to their experiences with virtual reality techniques and they were analyzed based on the theoretical findings.

2. ARCHITECTURE PEDAGOGY WITHIN 'INSTRUCTIONISM' UNDERSTANDING

According to Merrill (2007), a set of five instructional principles enhances the quality of instruction. These principles are task-centered, demonstration, application, activation, and integration.

The typology of architectural pedagogy as studio-based and project-based collaborative interaction work depends mainly on task-centered instructional strategies. The learner is asked to achieve increasingly complicated tasks while going through escalating design problem complexities. However, this dictates a well-defined instructional framework for tutors and learners to have the intended learning outcomes. Regarding the demonstration principle, the instruction has to follow a bottom-up approach (leads from more specific to more general), and it has to encourage collaborative peer engagement whether in discussion or in the demonstration. It also facilitates using media and new technologies as sources of demonstration that are related to the learned subjects. Regarding the application principle, the learner has to be guided to apply learning consistently with the type of developed skills.

Instructions related to corrective feedback are a cornerstone of the education process. However, the role of the tutor has to withdraw gradually to permit the learner to take over. Similar to other principles, the instructions given to engage learners in the peer-collaboration process are a core value in studio-based design. Regarding the activation principle, instruction has to build on the commutative experiences by activating, recalling, describing, and demonstrating the prior knowledge and experiences. Sharing with peers' previous experiences is another important instruction domain. Finally activating the continuously built up and developed learner-intrinsic knowledge structure and updating it with new knowledge is the focus of this instruction principle. Regarding the integration principle, instruction has to encourage learners to integrate new knowledge into already established his/her cognitive structures by experiencing them in new interventions. This could also be rooted in his/her knowledge by developing instruction that engages learners in peer-critique which is the main tradition in studio-based education. In addition, instruction has to work on the learners' personalities. It has to orient learners to develop personal techniques to activate their acquired knowledge and orient them to publicly show their knowledge and experiences.

2.1. Virtual Reality as Effective Tool in Architectural Pedagogy

Virtual Reality (VR) is a computer-based technology that enables the user to be completely involved in a 'micro-world' that presents much of the reality features (Onyesolu, 2011). It uses multisensory communication technologies to have people more interactive with the presented data, be it real or expected (Onyesolu et al., 2013). However, the potential of this immersing realm paves the way for its utilization in architectural pedagogy. It draws an innovative role for learners to construct their experiences and accordingly their knowledge. It allows them to act together with a computer- virtual milieu using their senses and reacting with their own bodies (Georgiou, 2007).

Sweller (2008), advocates for human brain understanding as a critical point for determining the type of technologies adopted and the way they are used in pedagogy. Cognitive Load Theory (CLT) explores the link between technology and cognitive paradigm. It presents a framework that is used to understand the way virtual reality (VR) technology is used in architectural pedagogy (Ritz, 2015).

Ayres & Paas, (2012), define cognitive load as a mental effort used by working memory. They classify it into three simultaneously working types; intrinsic, extraneous, and germane cognitive loads. While, the extraneous cognitive load results directly from the instructional design, the other two types are interrelated. The intrinsic cognitive load depends on the innate complexity of tasks, and the germane cognitive load deals with the amount of cognitive the learner allocate to deal with the intrinsic cognitive load (his/her cognitive capacity) (Meissner & Bogner, 2013). Optimizing the load between the three cognitive loads is the guarantee of successfully acquired knowledge. Regarding the complexity of architectural pedagogy and its challenging typology, it is argued that the intrinsic cognitive load has to be adequately controlled by instructional designers, and the extraneous cognitive load has to be reduced, and the germane cognitive load has to be enhanced (Meissner & Bogner, 2013).

2.2. The Role of VR in Attaining Cognitive Loads

The changes in architectural pedagogy brought by introducing new advanced technologies are drastic and fast. However, their impacts are subject to the way the tutors orient their learners. Actually, this is the challenge mentioned by Finkelstein et al., (2005). He asserts that "The real challenge is not in how to use new technology but in how to change the instructional design as a result of how technology affects pedagogy" (Finkelstein et al., 2005). The following part highlights the role of VR in attaining different cognitive loads.

2.1.1. VR role in attaining the intrinsic cognitive load

This cognitive type is related to the taught subject itself and its complexity. The role of the tutor is to divide the complex problem into a set of more reachable units (Ayres & Paas, 2012). VR is used usually to focus the attention of learners on the main points to build the needed comprehensive knowledge. As Finkelstein et al., (2005), mention "It (VR) is used to amplify and simplify content". This is practiced by using the potential of VR in exploring more details and focusing on the ingredients and their in-between relations to the overall scene.

'Reification' is a VR technique used to transform the intangible domain into a materialized one (Mikropoulos & Natsis, 2011). This is generally used when the problem is not concrete and the context is not reachable (extreme environment for example). The virtual realm permits the learners to experience what is not accessible in the real life (Winn, 2002).

2.1.2. VR role in attaining the extraneous cognitive load

This cognitive layer is directly connected to the instructional design. It is influenced by both the physical learning setting and the instructional materials (Sweller, 1988). Regarding the (VR) environment, instructional design has to create awareness about the relationship between real and virtual realms. The way the virtual realm expresses the real realm is quite important in this cognitive type. This would in its turn affect the quality of extraneous load. On the one hand, when the virtual realm is lacking the needed instructional information or having the wrong ones, it will cause the learner to move frequently between the real and virtual domains. On the other hand, the excessive amount of instructional data would cause what is called a "redundancy" effect (Meissner & Bogner, 2013). It would negatively affect the whole pedagogy process as it causes learners to consume their memory on inappropriate extraneous information.

To keep a successful instructional design, the 'split-attention effect' has to be avoided ((Sweller, 2008). The information given to the learner has to be in a condensed form to decrease the amount of working memory used to process these complicated data (Chandler & Sweller, 1991). Another important aspect to be considered is the physical setting and equipment used for the virtual realm platform. These new experienced media distract the learner's attention from the learning target. This is noticed using spatial equipment such as 3D glasses. As noticed most times, the novelty of the equipment and its easiness in use affect negatively the cognitive loads (Lim & Tay, 2010). A study performed by Bamford (2011) shows that the percentage of learners having negative side effects while using VR equipment decreases from 28% the first time to 4% in later stages.

2.1.3. VR's role in attaining the germane cognitive load.

This type of cognitive load shows the acting memory the learner dedicates to processing information. So, stimulating the learner's capacity is the core value of this cognitive type (Schnotz & Kürschner, 2007). The new technologies come the key aspect, as they have the ability to motivate the learners of the 21st Century (Gu, Zhu, & Guo, 2013). They are familiar with 3D movies, play video games, and use virtual technologies which make it easy for them to actively participate and encouraged them to engage in VR technologies applied to learning. While practicing the VR learning activities, the instructional designers have noticed that the learners are overwhelmed by a sense of being present and engaged similar to what is noticed while they are playing video games (Dickey, 2005). This is used to motivate learners to allocate a larger portion of their working memory to handle and manipulate more sophisticated knowledge. This has the potential to move the level of germane cognitive load to much higher and more complicated levels.

3. A FRAMEWORK FOR UTILIZING VR IN CORRELATING ‘INSTRUCTIONISM’ UNDERSTANDING APPROACHES IN ARCHITECTURE PEDAGOGY

Based on the above review, virtual reality is a technique that blends ‘Constructivism’ and ‘Instructionism’ in a (vicious circle) continuous process. Going through its application stages - virtual reality techniques- helps learners to construct their experiences using ‘Instructionism cognitive’ at its first level. Then, based on their gained experiences, learners move to ‘Instructionism cognitive level II’, which makes up the base for their upper level of constructed experience, and so on.

This dynamic ongoing process of cumulative escalating knowledge has to be built upon well-designed stages. The pace between ‘Instructions’ given at the beginning of the project, and the ‘Constructed’ experiences gained during the project has to be well managed and designed to keep the circle between these two consecutive stages as close as possible. Figure (2) shows a diagram of the ‘Constructivism’ and ‘Instructionism’ vicious circle.

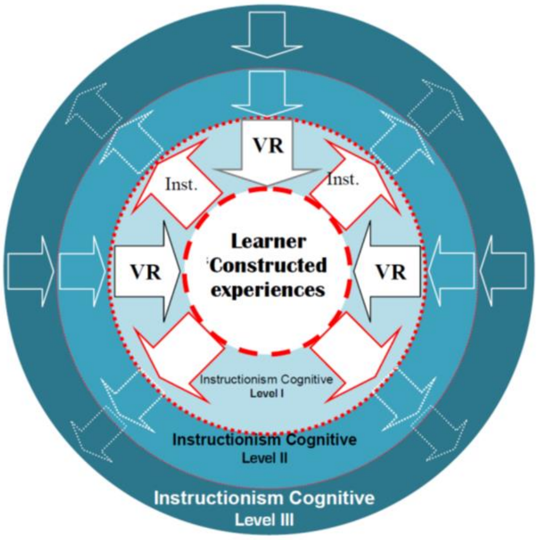

Fig.2: The ‘Constructivism’ and ‘Instructionism’ vicious circle in VR based architectural pedagogy. (Reference: The Authors)

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To guarantee proper rhythms of exchange between 'Instructions' and 'Construction', the instructions have to be tailored to attain many cognitive loads; intrinsic, extraneous, and germane as the first stage of this ongoing process. The second stage witnesses a blending procedure between 'Instructions' and 'Constructed experiences'. In this stage, the right following the five Instructional principles: task-centered, demonstration, application, activation, and integration guarantee the success of this stage (figure 3).

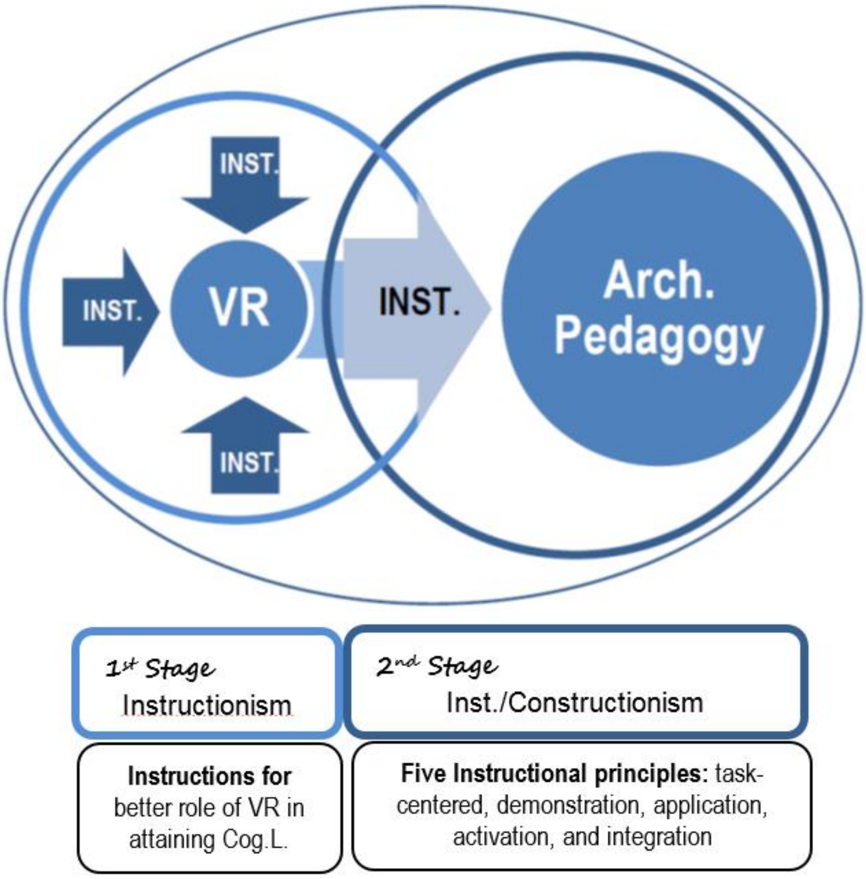

Fig.3: The successful exchange between 'Instructions' and 'Construction' in VR based architectural pedagogy. (Reference: The Authors)

4. FACULTY OF ARCHITECTURE, DESIGN AND BUILT ENVIRONMENT, BEIRUT ARAB UNIVERSITY CASE.

An experiment was performed on both 2nd and 3rd level students at the Faculty of Architecture, Design and Built Environment at Beirut Arab University (BAU). Students enrolled in the Urban Design course were asked to make their proposals to re-plan the Ain El-Remana district as on Mount Lebanon, Lebanon. Their proposal was on two different but compatible scales. On a macro scale, their interventions aimed at reconnecting the urban features of the area by proposing several infill projects. In addition, on a street level, in-depth studies were performed to get human-scaled proposals for more walkable and livable streets. This scale covers streetscape, façade design, street furniture, and landscaping elements (Figure 4).

The virtual reality lab in the Faculty of Architecture, Design, and Built Environment at Beirut Arab University (BAU) is equipped with recent trendy tools and equipment. The Faro 3D laser Scanner Focus (S-series) allows the possibility of scanning any space or building and the capability to modify or redesign it digitally. The VR lab is also equipped with 5 HTC Vive virtual reality goggles, 25 stand alone goggles, interactive touch projector, NVidia 3D glasses, and 3 MSI workstations for editing, rendering and control (Figure 5).

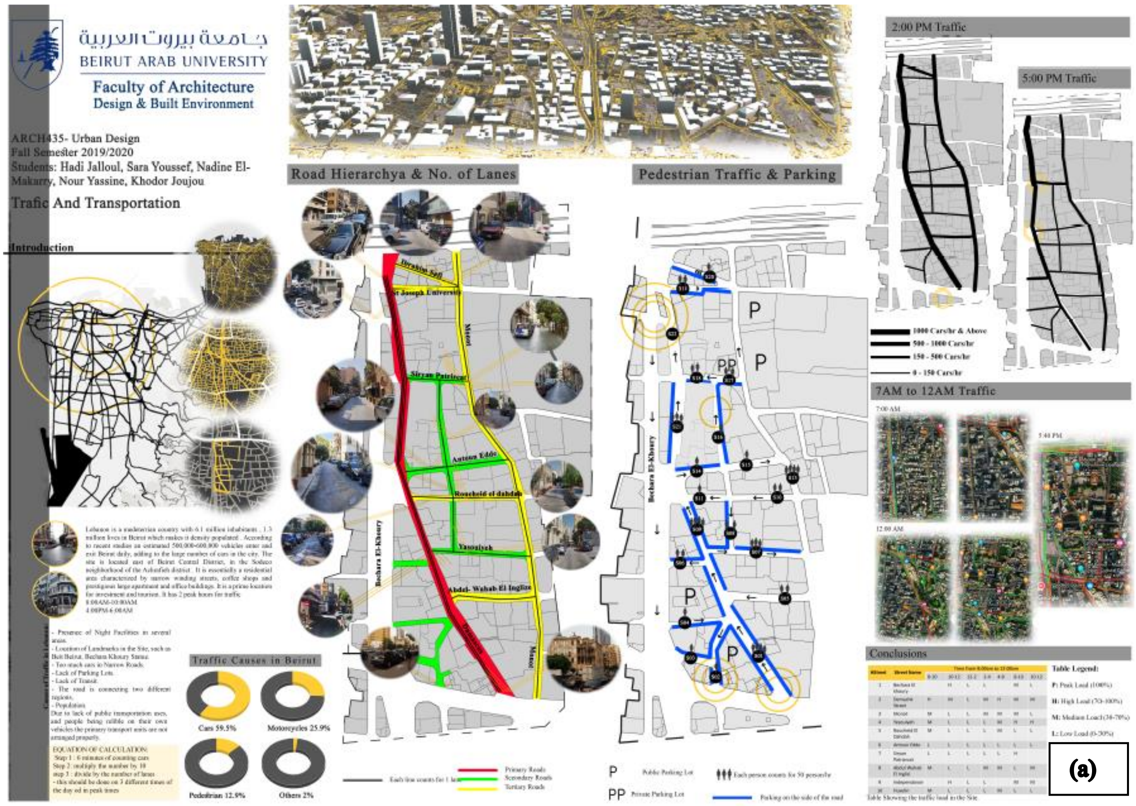

Fig.4:.(a) The project final submission format. (b) The VR lab during the experiment (Reference: The Authors)

- Devices used in this experiment are (figure 5):

- HTC VIVE Virtual Reality System (Wand + Oculus headsets + Motion tracking).
- MSI workstations Input and processing devices:
  - 6th Gen. Intel Core i7 processor - Intel Xeon.
  - DDR4 - 2133 Memory up to 64GB
  - 2 Data show projectors to display and share the HTC VIVE user experience on the screen.

Fig.5: The Devices used in this experiment (Reference: The Authors)

- **Software used in this experiment is:**
  - Twinmotion.
  - AutoDesk Infra Works.
  - Autodesk Rivet.
  - Sketchup.

The number of students enrolled in the course is 38 students (16 males (42%) and 22 females (58%)) the cumulative GPA of the students is: (2 students (less than 2), 2 students (2 - 2.4), 9 students (2.4 - 2.8), 15 students (2.8 - 3.2), 10 students (3.2 - 3.6), 0 students (more than 3.6)). Students were asked to evaluate their computer experiences and the results are as follows: one student is a beginner (2.5%), 6 students are having basic knowledge (16%), 19 students are having moderate knowledge (50%), 11 students are having an advanced knowledge (29%), and one student is having a very advanced knowledge (2.5%). Students were also asked to evaluate their experiences with virtual reality and with computer gaming (PlayStation, X Box, …etc.) and the results are as follows: 14 students are having former experiences with virtual reality (37%), while 24 students are not having any experiences with virtual reality (63%), 16 students are playing computer gaming (58%), and 22 are not familiar with these games (42%) (figure 6).

Fig.6: VR experiment a) instructions given by tutors, b) students performing the experience (Reference: The Authors)

The questionnaire is divided into two sections: the first asks about the role of VR in attaining cognitive loads: intrinsic, extraneous, and finally germane cognitive load. The final question in the second section asks about knowledge the students gained while going through this project. And the second section asks about the effectiveness of instructions given to guide learners to embed virtual reality in visualizing their development intervention. This section asks questions under the five key instructional principles that are responsible for enhancing the quality of instruction: task-centered, demonstration, application, activation, and integration.

5. FINDINGS AND DISCUSSION

Reading the questionnaire results concerning the role of VR in attaining cognitive loads shows that (figure 7):

- The responses of the students with no former experiences with virtual reality have scored higher than those who have experiences in this domain in four points (the role of VR in realizing more details about the project, involvement in the virtual domain during the experiences, the suitability of the virtual reality lab as a place for having a complete immersing experience, and finally the suitability of the used equipment to have this overwhelming experience.
- The responses of the students who have former experiences with virtual reality have scored higher than those who don't have experiences in this domain at one point (difficulty of the exercise compared to their previous experiences).

- The responses of both categories of students show a consensus on the positive role of instructors to simplify the assignment and its related tasks.

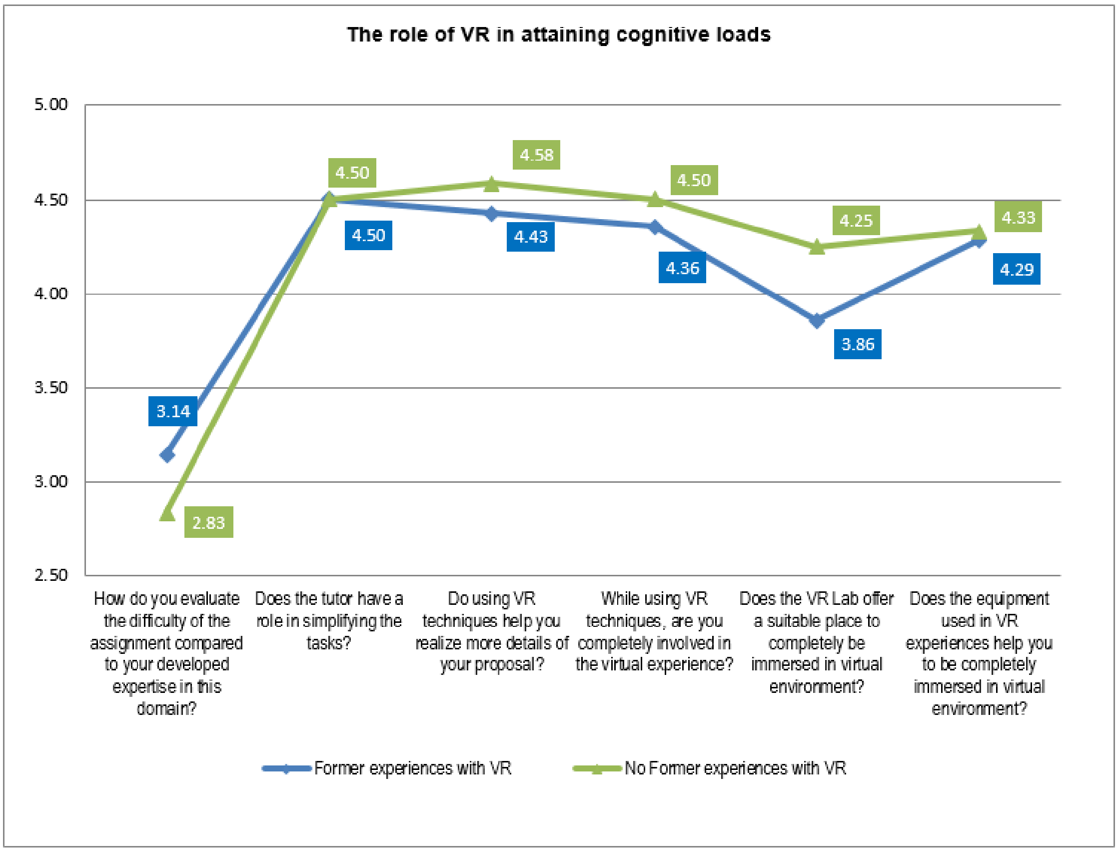

Fig.7: The role of VR in attaining cognitive loads (Reference: The Authors)

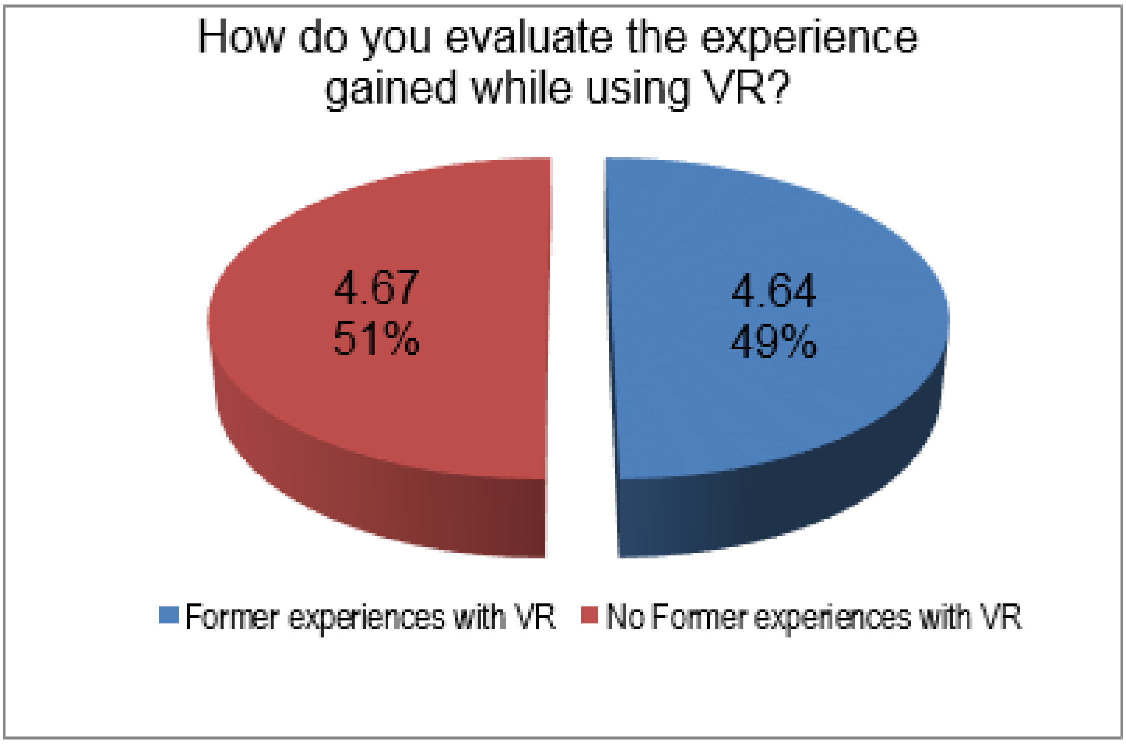

Fig.8: Students evaluation for their experience while visualizing their design using virtual reality techniques. (Reference: The Authors)

The last question of this part asks about the experience students gained while visualizing their design using virtual reality techniques. The responses of the students with no former experiences with virtual reality have scored slightly higher than those who have experiences in this domain, as shown in figure (8).

The second section asks about the effectiveness of instructions under the following five key principles:

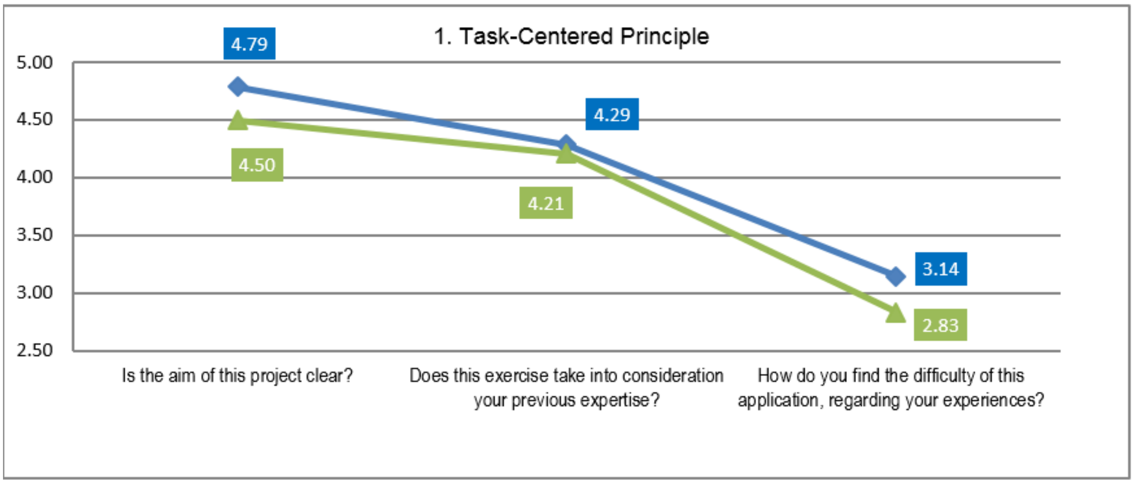

Fig.9: The effectiveness of instructions based on task-centered principle (Reference: The Authors)

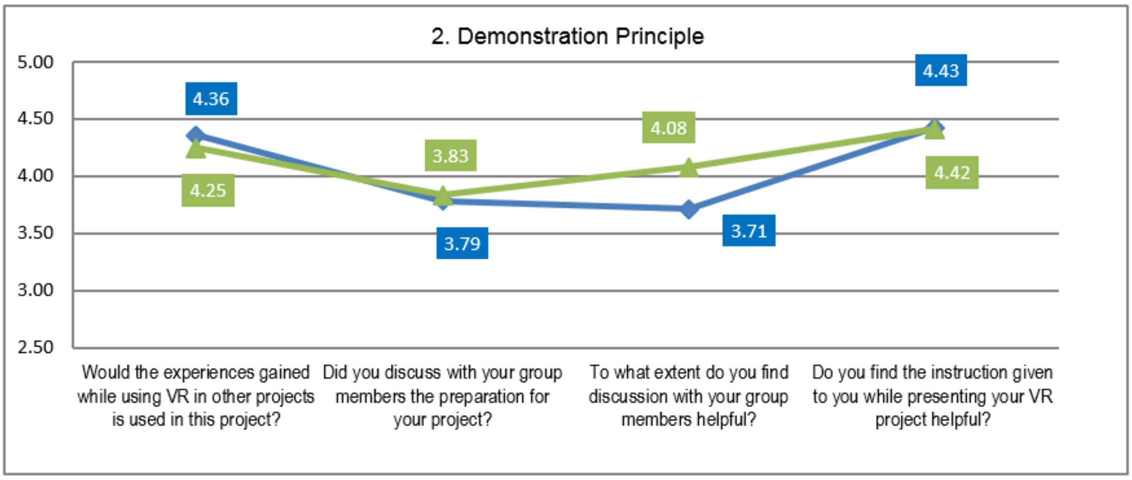

Fig.10: The effectiveness of instructions based on Demonstration principle (Reference: The Authors)

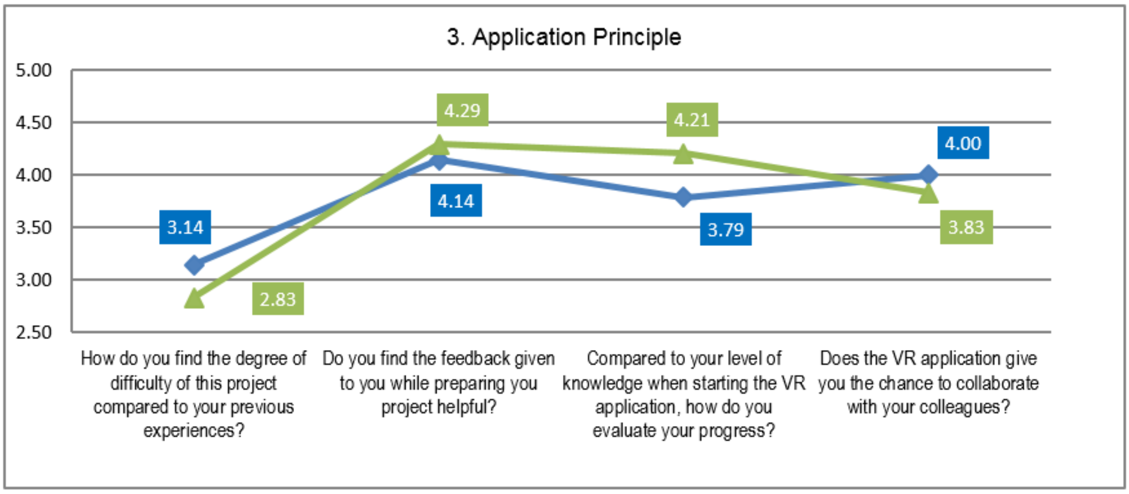

Fig.11: The effectiveness of instructions based on Application principle (Reference: The Authors)

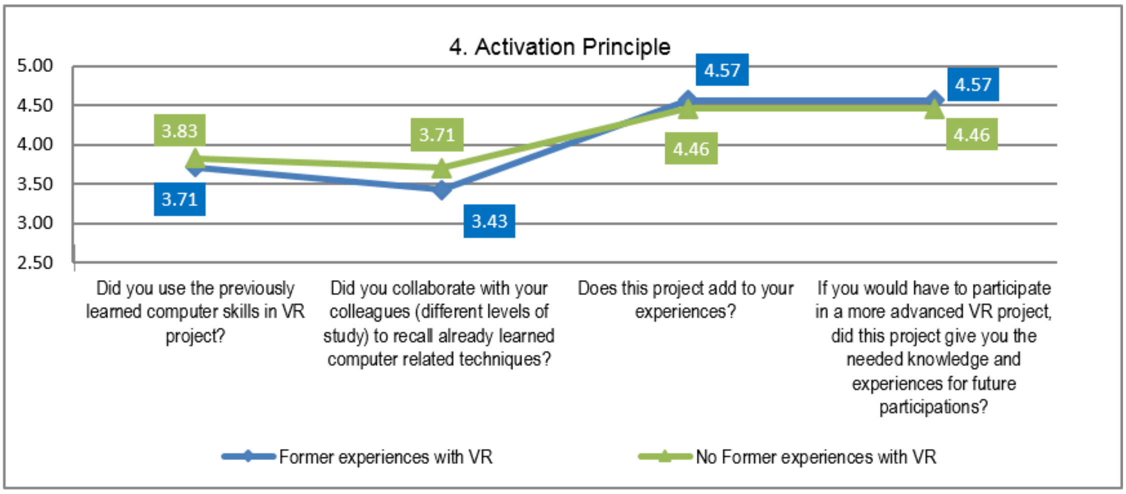

Fig.12: The effectiveness of instructions based on Activation principle (Reference: The Authors)

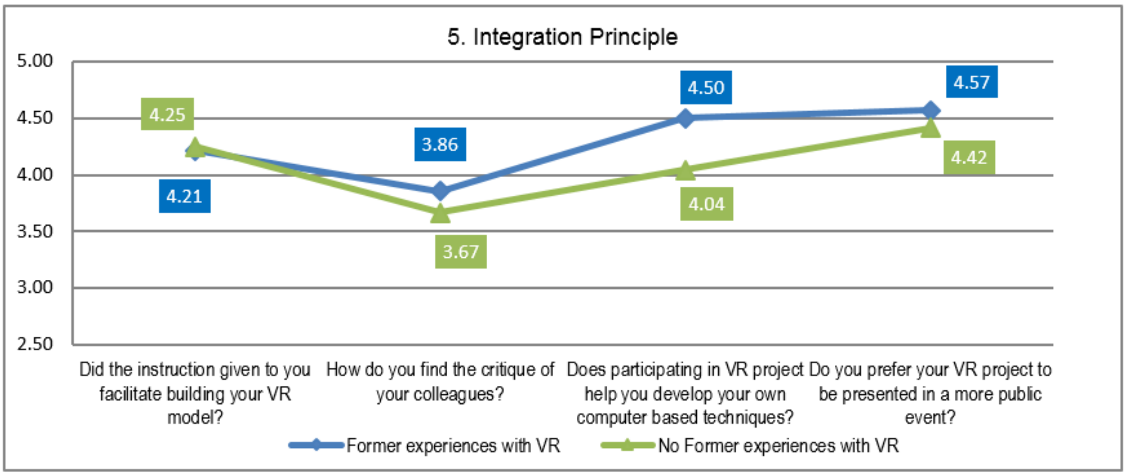

Fig.13: The effectiveness of instructions based on Integration principle (Reference: The Authors)

- Discussion:

The questionnaire's results could be interpreted within the outlines of the proposed framework. The results show a clear variation between students who are well-experienced with virtual reality techniques and those who are going through the process for the first time. This could be seen as a reflection of the practiced recurrence between 'Instructionism' and 'Constructionism' in the well-experienced students. Their gained experiences helped them to construct their own vision, knowledge, and expertise that qualify them to re-evaluate the effectiveness of instructions. This applies to the education media and the lab's facilities as well. Yet, the low scores of the well-experienced students compared to the beginners in many items of investigations could be interpreted as they benchmark the new experiences to their already constructed knowledge. This could be seen in their judgments about acquiring more details when using VR techniques, and about the virtual reality lab as a place and as equipment. As consistent with this argument, the well-experienced students score high when asked about the degree of difficulty of the exercise compared to their previous experiences. This also supports the hypothetical logic of the developed framework. As going through the process the constructed knowledge is going more in-depth and the new tasks become easier.

The results scored in all of the five principles reflecting the effectiveness of instructions given to students before and during the project concurring with the above-mentioned argument. The detailed aspects are as follows:

- Regarding the 'Task-Centered Principle', the previously experienced students score higher than the beginner students in all aspects. They see the aim of the project clearer; build on their previous expertise, and finally see the current project as easy compared to their colleagues.
- Regarding the 'Demonstration Principle', all students -regardless of their previous experiences in the Virtual Reality domain- are almost having the same score two folds. They see the instructions given to them while preparing and presenting their projects are very helpful (scored the highest among all aspects). In addition, the discussions among the group members are important. However, the experienced students see these discussions as less worthy compared to the students who are beginners in this domain.
- Regarding the 'Application Principle', concurring with the framework's argument, the well-experienced students find the tasks easier and the preparation for the projects opened potential –based on their previous experiences- to collaborate with their colleagues. Meanwhile, the values scored by the well-experienced students are relatively high (4.14, and 3.79) concerning the extent to which the feedback is helpful and the progress they achieved while going through the project consecutively, the scores of these two items are higher for the beginner students.
- Regarding the 'Activation Principle', two folds could be extracted out of the results. Firstly the challenge initiated when collaborative work between the well-experienced and less-experienced students is responsible for pushing the latter to recall and use the previously learned skills, and to collaborate more effectively with their colleagues to acquire more knowledge. Secondly, the very high score achieved by all the students (with a slight difference between the well-experienced (4.57), and less-experienced students (4.46)) when they were asked about their gained experiences while going through this project and their satisfaction with their preparedness for participating in more advanced VR projects based on their current experience.
- Regarding the 'Integration Principle', differences in scores between the well-experienced and less-experienced students indicate the impact of the cumulative experiences in enhancing the capabilities of the students. The well-experienced students marked positive in both having tolerance regarding their colleagues' critique, and their capabilities' development of computer-based techniques. In addition, all the students enrolled in this experiment (with a slight difference between the well-experienced (4.57), and less-experienced students (4.42) were proud of their product and they would prefer to present their work in a more public event

6. CONCLUSIONS

Architecture pedagogy is a dynamic domain as it accepts continuous updates based on all the new theories and innovative practices. Lately, these updates are profoundly shaped by the emergence of new technologies. However, these waves extended beyond the means to redefine the well-established aims of this educational process as well. Virtual Reality is one of the fast-growing computer-based technologies that have many applications in the architecture profession and education. Now, being aware of this technology and its related techniques is indispensable in modern schools of architecture. However, this has to go in parallel with complete awareness of the classical theories of this domain to keep balanced updates to its both aims and means.

The proposed framework –as the main finding of this paper- is exploited to establish a theoretical understanding of embedding Virtual Reality techniques within the well-established 'Instructionism' and 'Constructionism' theories of architecture pedagogy. In these regards, virtual reality is seen as the trigger for a hesitating movement between 'Instructionism' and 'Constructionism' poles. Instructions given to students help them to have an initial awareness about the required tasks and the practice pushes them to construct their knowledge and consequently skills. This vicious circle between 'Instructionism' and 'Constructionism' is practiced many times during the project to develop students' capabilities to acquire new knowledge. Virtual reality as a computer-based application proved its ability to attract architects

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to interact positively with this process and to gain direct and indirect skills that would help them in their careers.

This paper uses the results of a questionnaire performed at the Faculty of Architecture, Design and Built Environment, Beirut Arab University, Lebanon to validate its proposed framework. These results assert that:

- Virtual reality as a computer-based technology could be used as a media to correlate ‘Instructionism’ and ‘Constructionism’ understandings. This would be of great benefit to architecture pedagogy as the students would reflect these correlations to their architecture practices.
- Having a mixture of students with a different awareness of virtual reality techniques in group work would be of significant gains. More chances for ‘Instructionism’ /‘Constructionism’ cycles of inquiry will be initiated, and consequently, more students’ collaboration is expected.
- Gained experiences have clear leverage on the constructed knowledge. So, critical judgments are presented by more experienced students. This continuous cycle develops more in-depth visions that the students have while proceeding in their architecture careers (whether in education or professional practice).

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