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Immersive Virtual Reality and The Appreciation of Architectural Aesthetics

Sürükleyici Sanal Gerçeklik ve Mimari Estetiğin Takdiri

Abdurrahman Mohamed[1], Hilal Tuğba Örmecioğlu[2]

Öz

Doğası gereği yapılı çevre insanları kendi üç boyutlu boşluğuna sokar ve bu nedenle onlara özel ve üç boyutlu estetik deneyimler sağlar. Bu deneyimler, bilinen görsel sanat eserlerini deneyimlemekten farklıdır. İki boyutlu analog mimari sunumlar, mimari mekan hakkında bu tür deneyimler sağlayamaz. Bu deneyimler, üç boyutlu olmamasından ötürü, mimari boşluğu bilgisayar ekranı aracılığı ile sunan Sanal Gerçeklik (VR) ile de elde edilemez. Üç boyutlu sanal gerçeklik (IVR), izleyiciyi dış dünyadan ayıran ve onu sanal ekrana çeken CAVE ve Başa Takılan Ekran (HMD) gibi özel yazılım ve donanımlar, üç boyutlu ortam deneyimi sağlamanın bir yolu olarak ortaya çıkmıştır. Özellikle mimari tasarımda yeni tasarlanacak projeleri araştırmak için kullanılmıştır. Mevcut binaları keşfetmek için IVR kullanımı çok yaygın değildir. İnşa edilmiş ve inşa edilmemiş mimari projelerin estetik niteliklerini değerlendirmede IVR'nin kullanımı ise nadiren yaygındır. Mimari eğitimde IVR kullanımı, hem öğrencilere bina ve tasarım çalışmaları için üç boyutlu deneyimler sunmak üzere yaygın değildir hem de öğrenciler tarafından çalışmalarını stüdyolarda sunmak için kullanılmaz. Bu araştırma, mimari estetiğin değerlendirilmesinde IVR'nin kullanımını inceleyen birkaç örnekten biridir. Bu çalışmada Bahreyn Üniversitesi Mimarlık ve İç Mekan Tasarımı Bölümü'nde gerçekleştirilen bir ders kapsamında bir grup kız öğrenciye, çevresel estetik üzerine IVR'yi tanıtan bir deney sunulmuştur. Öğrenciler, hem IVR hem de binanın fotoğraflarını kullanarak gerçek bir binanın mimari estetiğini karşılaştırmalı olarak değerlendirmişlerdir. Fotoğraflara kıyasla IVR'nin, öğrencilerin binanın mimari estetiği hakkındaki değerlendirmelerini önemli ölçüde geliştirdiği keşfedilmiştir. Ayrıca öğrencilerin IVR hakkında çok az bilgiye sahip oldukları ve IVR'yi etkin bir mimari eğitim aracı olarak kullanmaktan yana oldukları tespit edilmiştir.

Anahtar Kelimeler: Mimari, sanal gerçeklik, sürükleyici, estetik, takdir, katılım.

ABSTRACT

The built environment immerses people within its three-dimensional space and provides them with immersive aesthetic experiences. These experiences are different than experiencing normal artworks. Therefore, the two-dimensional paper architectural presentations cannot provide such experiences because they are non-immersive. Neither can these experiences be achieved by non-immersive Virtual Reality (VR) on computer screens. Immersive Virtual Reality (IVR) has emerged as an experience of the three-dimensional environment using special software and hardware like CAVE and Headset Mounted Display (HMD). They cut the viewer from the outside world and immerse him in the virtual display. It has been used in architecture to explore newly designed projects. The use of IVR to explore the aesthetic qualities of architectural projects is less common. The use of IVR in architectural education is neither common for giving the students immersive experiences for the study of buildings and designs. This research is among the few examples to study the use of IVR in the evaluation of architectural aesthetics. It presents an experiment introduced IVR to architecture students as part of a course on environmental aesthetics. The students conducted a comparative appreciation for the architectural aesthetics of a real building using both its IVR and photograph

[1] **Corresponded Author |** Antalya Bılım University Faculty of Fine Arts and Architecture Department of Architecture, a.mohammed@antalya.edu.tr, ORCID: https://orcid.org/0000-0002-0103-5622

[2] Akdeniz University Faculty of Architecture Department of Architecture, ormecioglu@akdeniz.edu.tr, ORCID: https://orcid.org/0000-0002-0662-4178

prints. It was discovered that IVR significantly improved *students' appreciation of the architectural aesthetics of the building compared to the photographs. It was also discovered that students had little information about IVR and they were in favor of using it as an effective architectural education tool.*

Keywords: Architecture, virtual reality, immersive, aesthetics, appreciation, engagement.

INTRODUCTION:

The role of aesthetics in developing the visual quality of architecture has been for centuries affecting and directing the development of architecture. For long period of this evolution, the main concentration was directed to the artistic physical components of architecture in a way like the aesthetics inquiry in the visual arts. Two main frameworks were developed for the control of the aesthetics quality in architecture. One framework was object-oriented. It looked at the physical characteristics like material, color, texture, form, size, and volume (Grazuleviciute-Vileniske et.al., 2021). The second framework was subject-oriented and considered the principles that contribute to the aesthetic visual qualities like proportion, symmetry, balance, contrast, pattern, unity, and rhythm (Vinchu et.al., 2017). To discover architectural aesthetics, there is always a need to experience its visual compositions visually and imaginatively. To do this, visual perception is not enough. It is necessary to be engaged with the architectural space. This is because people are usually wholly enclosed within this space and its spatial and functional arrangements (Kulczak-Dawkins,

2001). The need for creative solutions for architects, educators, and students to have easy, simple, and cheap immersive engagement with the architectural space necessitates the search for immersive virtual reality technologies that can at least partially fulfill this goal. Berleant and Carlson (2007) considered this engagement as a requirement for the appreciation of environmental aesthetics where people themselves become part of the environment both built and natural. Environmental aesthetics engagement is affected by many physical, spatial, and human factors. Examples of these factors include space, form, time, movement, light, smell, sound, and tactility. In addition to these factors, visual design principles like proportion, pattern, and order are also important (Berleant & Carlson, 2007). Based on this concept, Berleant (2013) came up with a definition for aesthetics engagement. It is the activity that "emphasizes the contextual character of aesthetics appreciation, involving active participation in the appreciative process". This concept is also applicable to architecture where the engagement of people in the architectural space is the only way for experiencing it functionally and aesthetically. With this kind of engagement, people are immersed in the architectural environment and live all its particularities. At this stage of spatial experience people will be able to appreciate the aesthetics of architecture with all their senses responding to all its aspects not only visual compositions. They will be talking, walking, sitting, touching, and smelling.

There is an increasing intention of architects and designers to consider these factors in their practice (Spence, 2020). Architecture can be fully understood by this live experience which cannot be substituted by the non-immersive architectural presentations on paper or computer screens. Both produce presentations on 2 dimensional planes with which the viewer can be engaged in the same way of engaging with visual art objects. The appreciation of architectural aesthetics in this case will be confined to the visual art qualities. It is left to the viewer to imaginatively explore the 3D spatial composition of the design. Physical and virtual models and perspectives help to aid this imagination (Popkonstantinovic et al, 2011). Walk-through digital videos help also in this regard, but never can they provide immersive spatial and aesthetical experiences. The development of IVR in addition to Augmented Realty (AR), Mixed Realty (MR), Arch-Explore and other technological applications provide promising opportunity for building and disseminating immersive virtual reality for studying, exploring, and analyzing the built environment. Yet unfortunately, when it comes to the systematic study and

analysis of architectural aesthetics few studies can be found. Some studies concentrate on the philosophical and ontological backgrounds of the relationship between aesthetics and the technology (Antomarini & Berg Eds., 2013). Other studies presented the technological advancement in the field and their applications mainly for the virtual visualization and space exploration (Chen & Fragomeni, Eds., 2018, Diec et al, eds., 2021, Whyte, 2002, Eloy, et al, Eds., 2022).

This research is a response to this shortage and provides an attempt to study the effects of IVR on the appreciation of architectural aesthetics. It was the result of discussions in the Environmental Aesthetics course offered for the first time by the main author in the Department of Architecture and Interior Design, University of Bahrain. The curriculum of the architecture program was inspected with all its 53 courses with 167 credit hours. It was discovered that none of the courses was fully or partially directed to aesthetics or VR. Aesthetics was mentioned superficially in some courses like basic design or to denote the general visual qualities in some architectural design studio courses. Similarly, VR was mentioned in the two compulsory courses of CAAD and the elective course on Advanced CAAD. These findings raise the attention to consider the inclusion of these two subjects in their curricula.

For the limitation of resources, the study could only use HMDs and the associated software and hardware. The persons participated in the experiment were female architecture students and they only examined architectural aesthetics in one building for one time during the academic semester. This was due to cultural, social, and time constraints.

1. Immersive Virtual Reality and architecture

With the development of computer technology, Computer Aided Design became the main tool for the creation and development of architectural design and continued to provide the medium for virtual reality (Abdulhameed, 2013). Virtual realities provide the viewers with simulations of the architectural environments. Non-immersive VR has been used as the main tool of architectural education and practice since decades (Whyte, 2002, Aydin & Aktaş, 2020). Its main function has been limited to digital presentations on screens and as a drafting tool. The concept of virtual immersion requires that the viewer is immersed in the virtual environment by being cut from the outside world (Bates, 1992). If the viewer cannot feel the spatial enclosures of the 3D space, the immersive engagement with the architectural space is missed (Seo, 2011). This immersion is usually created by computer hardware and software to provide a “make-me-believe” or “being there” virtual environment. Immersive Virtual Realty (IVR) and Augmented Realty (AR) both concentrate on the creation of more realistic virtual realties with more immersion capabilities (Achten, 2022). The use of HMD, CAVE Virtual Walls, and Arch-Explore user interface are among the most common methods in this practice. In the HMD system, the user can experience individually the VR environment with the help of a headset. CAVE and Virtual Walls, and Arch-Explore user interface are so expensive and require high budgets that are not available for many universities and schools of architecture (Machado S. et al, 2004). In whichever method preferred, it is worth mentioning here that this immersive virtual environment can only provide audio-visual immersion with limited movement or touch possibilities for their complexity. Other aspects of the 3D architectural environment only can be imagined with the aid of the IVR used (Seo, 2011). The importance of this imagination is to generate a viewer’s sensory responses to the IVR like the sensory responses to the real environment (Slater et al, 2009). This is clearly observed when the viewer walks or bends as a response to the immersive virtual space he is observing or raise his hand to touch virtual surface. The state of these responses is sometimes termed presence (Bates, 1991, Slater et al, 2009) which denotes to the interaction of the viewer with the virtual reality and the action they take accordingly. The important aspect of both is the ability to transfer the viewer’s senses to the world of the virtual reality. This help to perceive the real space in a better way. Another important aspect is their ability to use illusion to enhance the imagination of the viewer and bring his experience of the

architectural space closer to reality (Bartlem, 2005). İt creates a sense of fusion between the viewer and the virtual space and thus make him more immersed in this space (Bruder, et al, 2009). Although the amount and level of immersion or presence are disputed, it is agreed upon that the ability to bring architecture and the built environment in general to the world of IVR brought a distinguished shift in the study of them both (Bowman, & McMahan, 2007). VR is immersive. It is "as a fully immersive digital and stereoscopic visual experience (Schipper & Holmes, 2022). This highlights the need to change the perception of many in the academia and the profession that VR is only limited to normal digital presentations on computer screens or projector boards. This perception has for long cut many architects and schools of architecture from following the great developments in the immersive technology and its applications in design disciplines. IVR in addition to Augmented Realty (AR) and mixed realty (MR) are getting increased momentum recently form digital labs in the profession and some schools of architecture to exploit their immersive capabilities to bring architectural and urban design concepts more easily to people. Or in other words to take people more easily to the virtual words where they can live these concepts as close to reality as never happened before.

2. IVR and the study of architectural aesthetics

The development of computer technology and Information Technology and Communications (ITC) has brought unprecedented challenges to culture and values of beauty and aesthetics (Kinzler et. al., 2022). Ideas, values, principles, and norms are easily, widely, and quickly disseminated affecting huge masses of people. Aesthetical values have been shared, discussed, and examined globally especially in visual arts and design. The role of IVR has been significant in this struggle with applications in TV, cinema, health, architecture, and video games (Antomarini & Berg, Eds., 2013, Chen & Fragomeni, Eds., 2018). Architecture is no exception. IVR has been providing greater opportunities for the study, analysis, and development of design. Its interactive experiences of the 3dimensional space improve the understanding of space (Bruder, et al, 2009). With the flexibility of user controls over the virtual space, IVR increases the capacity to build mental models of the architectural space and bring closer attention to its details and different aesthetical values. IVR has shifted the traditional perception of the built environment to a wider and deeper spatial "virtuality" that provides new opportunities for inspecting the space and examining different alternatives of its design (Kim & Kim, 2019). It has strong expressive abilities that can be used to enhance users' appreciation of the aesthetical qualities of the space (Kim, 2016). The immersive qualities of IVR provide greater sense of spatial presence that strongly connects the viewer with the space and its details and affect his senses and feelings and behavioral responses (Bowman, & McMahan, 2007). Architectural aesthetics are integral part of the presented architecture in IVR and deserve to be considered during the IVR exercises. Unfortunately, most of the studies concentrate on other issues considered more important like the movement, touch, and audio effects. It is even claimed that the "aesthetic dimension has still not been fully explored" in IVR (Achten, 2022). Bruder et al (2009) experimented how Arch-Explore user interface can be used for IVR architectural walkthrough. Although the main concern was directed to the control of the viewer's movement in the virtual space, it provided insights on how virtual textures and colors can be experienced. Paes et al (2017) conducted an experiment to study the difference between using normal non-immersive VR with the IVR platform in the architectural design process. They found that IVR significantly improved the perception of the virtual model. Aesthetic was not a concern of the experiment but of course it was part of the virtual model, and it can be understood that IVR improved the perception of the virtual aesthetics of the model.

A review has been conducted for one of the latest titles in the field "Virtual Aesthetics in Architecture-Designing in Mixed Realities" (Eloy, et al, Eds., 2022). It revealed that it did not consider architectural aesthetics as a design framework that has its principles and guidelines to produce beautifully

satisfactory architecture. It did not consider how this architectural aesthetics can be explored, analyzed, and assessed in IVR and its applications.

IVR technology and all its applications with their software and hardware have been undergoing great efforts of development. In the field of architectural design practice and education, still there is a lot to be done to make it a common practice in the education studio and the design firm. Also, there is a need to pay attention to the importance of IVR for understanding the emerging concepts of environmental aesthetics which still need to be carefully introduced to the architecture world. This research is an attempt to open a door of interest in these important issues.

3. Methodology

The use of comparative studies for exploring the difference between IVR and normal photographs on the perception of architectural space was used by Aitamurt et. al. (2018). A similar experiment was conducted by Krinizki et. al. (2021) to study the different space perceptions when being in the space, experiencing its images on the computer screen and experiencing its IVR. Although both experiments did not consider architectural aesthetics in their programs, they proved the significant effect of the IVR in improving the users' perception of space where aesthetics is an integral part of it.

This research intended to study the difference between the effect of IVR and normal photographs on the users' appreciation of architectural aesthetics in an existing building. The participants were female architecture students in the Department of Architecture and Interior Design, University of Bahrain. The research concentrated solely on the students' evaluation of the architectural aesthetics of the building with the elimination of all other factors that might affect this evaluation like psychological, cultural, social backgrounds, or ideology (Hubbard,1996). For this purpose, there was a need to decide upon the following points:

- The aesthetic qualities to be used for the measurement of aesthetic appreciation of the students.
- The sample of the students participating in the experiment.
- The building to be appreciated.

3.1 Aesthetic qualities

It has been discussed above that there are two main frameworks used for the study and analysis of architectural aesthetics. For this research, a set of measures from both frameworks were used. The measures in this set were chosen mainly depending on the educational background of the participating students and the curriculum of their architecture program. Other measures were also added, and the final list included:

- Form
- Facades
- Details
- Materials
- Colors
- Proportions

These measures were used to design a Likert questionnaire with a scale from 1 to 5 where 1 is the lowest and 5 is the highest. The measures outlined above were used in 2 parts of the questionnaire. The first was to measure students' appreciation of the architectural aesthetics of the building from its photographs. The second part measured the appreciation of the architectural aesthetics of the building

by using IVR as explained in the experiment section. The final set of measures used are shown in Figure 6 and they include:

- Building form and masses
- Proportions of solid and void
- Proportions of solid and glass
- Facades of the building
- Details of the building's facades
- Shape of windows and doors
- Building materials used
- Colors of the building
- Overall exterior of the building

The questionnaire also included parts on the students' knowledge and understanding of aesthetics and virtual reality technology. The last part of the questionnaire measured students' evaluation of the use of IVR in architectural education.

3.2 Students' sample

Random sampling was used to choose a group of female architecture students. The reason behind this choice was the belief of the research team that female students in the department were more in desperate need of the understanding and use of both aesthetics and IVR. This is in addition to cultural and social issues specific to the Bahraini society's perception of mixed experiments of this type. The total number of participants was 25 students representing the 5 levels of the 5-years architecture program.

3.3 The building

The Bahrain Fort Museum café was chosen as a case study for the students to assess its aesthetics using photographs and IVR. The building was chosen randomly without any comparative analysis and without conducting any qualitative or quantitative evaluation. The decision depended upon several qualities that helped to conduct the experiment. Several points were taken into consideration:

- Ease of access and permission to take photographs and create the VR of the building.
- Simple architectural form to help students easily assess its aesthetics.
- Outdoor extension where the students can walk around.
- Reasonable size of the building.

The research did not attempt to study the relationships between the function of the building and its aesthetic features and qualities. Although it is possible to categorize the aesthetical qualities in architecture (Jennatha & Nidhish, 2016), the research did not use any of these categorizations.

4. The experiment

The experiment was conducted completely one time during the same academic semester. The photographs of the building were taken using a Samsung Galaxy S8 camera. They were printed on normal white A4 paper. Figure 1 illustrates one set of photographs shown to the students during the experiment. The 360-degree VR of the building was created using a Samsung Gear 4k 360 camera. It was then uploaded to the Samsung Galaxy S8 smartphone with Samsung Gear App to view the 360 VR. The Samsung Galaxy S8 smartphone was then used with VR Box 3D Virtual Reality Glasses (Figure 2) to create the IVR that students were subjected to.

The experiment took place in the outdoor spaces of Isa town Campus of the University of Bahrain. No spatial settings were prepared, nor special arrangements were seen necessary. The only precaution was to avoid any sonic effects within the atmosphere of the experiment for their ability to affect aesthetics appreciation of the students (Mohamed, 2020). Time and spatial settings of the experiment given were the same for all the participants. The students initially answered the first part of the questionnaire of the general information and their knowledge of aesthetics and VR. Then they were engaged individually with the photographs of the building. They all were shown the same photographs of the building with the same quality. This step was followed by answering the part of the questionnaire on the appreciation of the building's aesthetics. Afterwards they individually had the immersive experience of the VR of the building. Then they answered part 3 of the questionnaire on the IVR appreciation of building's aesthetics. The participants then answered the last part of their views on the need to use IVR in architectural education.

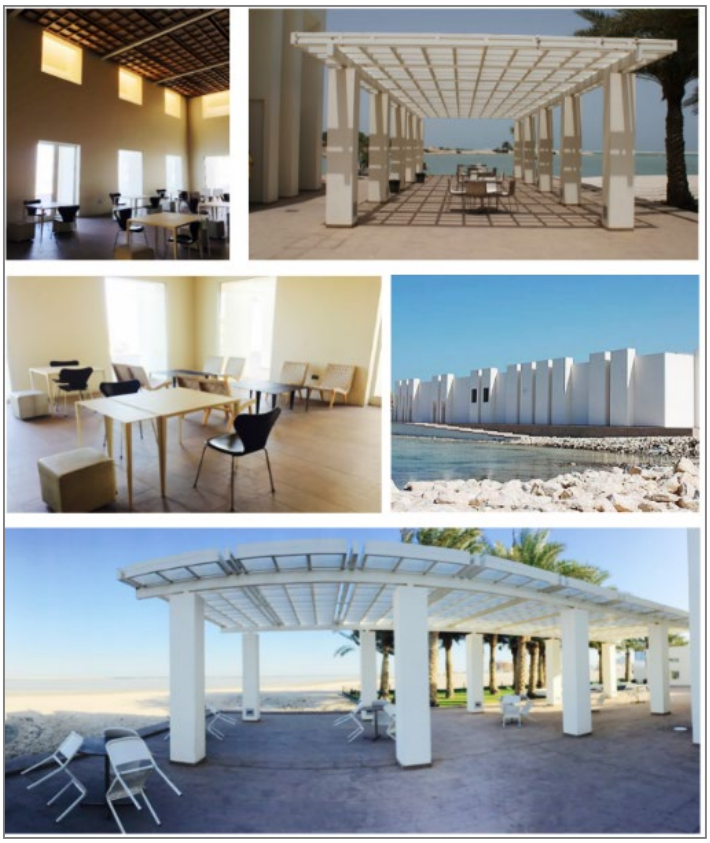

Figure 1: The set of photographs of the building shown to the participants

Figure 2: Students while using the HMD to evaluate the architectural aesthetic of the building

5. Results and analysis

The results of the questionnaire were studied and analyzed under four main topics, which are students' knowledge of aesthetics and VR, Students' evaluation of architectural aesthetics of the building, Students' overall evaluation of the architectural aesthetics of the building, and Students' evaluation of the importance of IVR for architectural education. The results are shown in figures 3 to 6. They are discussed in the following points.

5.1 Student's knowledge of aesthetics and VR

Figure 3 shows the relationship between students' knowledge of aesthetics and VR and their level of education. It is clear in the figure that the knowledge about aesthetics and VR technology is very low in the first two grades of the architecture program. The knowledge of VR only reaches over 60% in the third grade and above while the knowledge of aesthetics reaches 80% in the 4th and 5th years.

5.2 Students' evaluation of architectural aesthetics of the building

In the second part of the study, the students were asked to evaluate the building using the nine variables mentioned in "Aesthetics qualities" above. Figure 4 shows the overall evaluation of the students' appreciation of these measurements using both the photographs and IVR. As seen in the figure, there is a clear difference between the two techniques which implies the positive effect of the IVR on the students' appreciation of architectural aesthetics. The curves of evaluation of the student's appreciation of the 9 measurements using both the photographs and IVR are not parallel. In the photographs' evaluation, the highest measures were building form, facades, and overall aesthetics and they got between 60% and 70%. In IVR evaluation, the highest measures were building form, Façade details and overall aesthetics and they got above 80%. Moreover, the figure shows that the highest evaluations in the photographs went to proportion and overall exterior of the building. At the same time, the highest evaluation in IVR went to façade details. This gives an indication that in photographs students were more attracted to the main architectural elements of the building and their relationships.

5.3 Students' overall evaluation of the architectural aesthetics of the building

Figure 5 shows the difference between the overall evaluation of the architectural aesthetics of the building using photographs and IVR by students' level of study. For all levels of students, the effect of the IVR on the appreciation of the architectural aesthetics of the building is well presented.

5.4 Students' evaluation of the importance of IVR for architectural education

Like the previous results, the fourth analysis showed that the students' evaluation of the importance of IVR technology in perceiving architectural aesthetics increases by level. As the students get knowledge about the technology over time, they appreciate its effects more. When this is accompanied by the results of part one of their knowledge of aesthetics and VR, it gives a clear indication that they did not get enough knowledge and training on these two important subjects.

CONCLUSION

This research highlights the importance of IVR for better understanding of the architectural space and its details including architectural aesthetics. It also raises the attention towards the need for a shift in the perception and application of IVR to be a tool for the assessment of design aspects of the architectural space

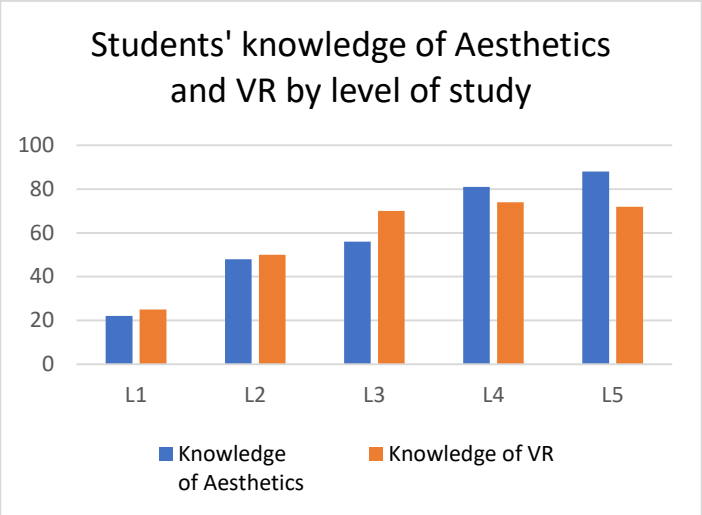

Figure 3: Students' knowledge of aesthetics and VR by the level of study

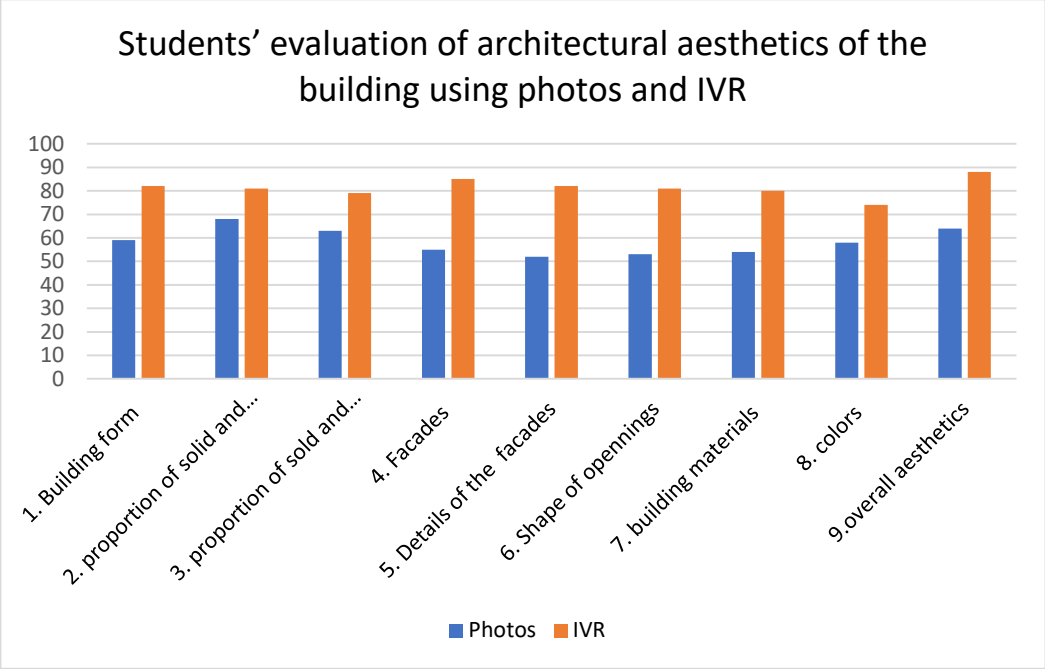

Figure 4: Students' evaluation of architectural aesthetics of the building using photos and IVR

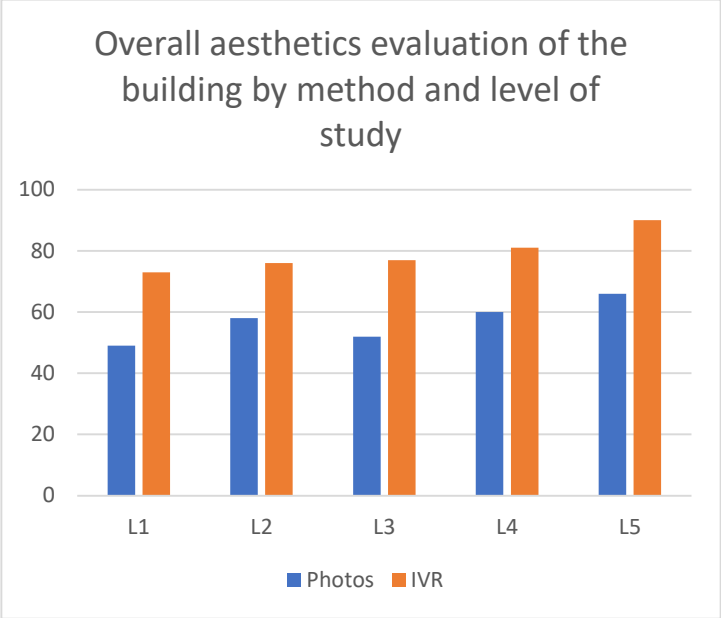

Figure 5: Overall aesthetics evaluation of the building by method and level of study

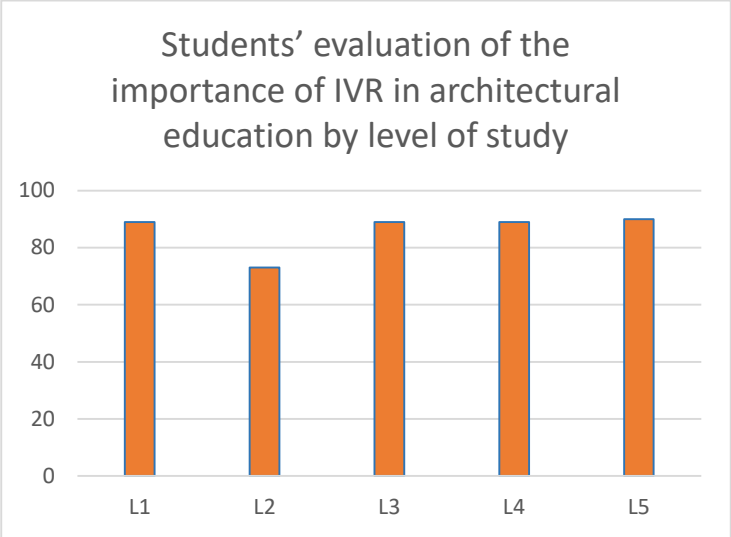

Figure 6: Students' evaluation of the importance of IVR in architectural education by level of study

and its details. It is believed that many schools of architecture and many professionals need to give more attention to the importance of both aesthetics and IVR in developing design skills and performance. The experiment of this research showed that although there was an improvement of students' knowledge of aesthetics and VR in the higher grades, the results highlight the need to pay more attention to these two important issues at the early stages of architecture programs.

At the same time, although the second part of the experiment showed considerable improvement in aesthetics appreciation with IVR, there were differences in the details of this appreciation between IVR and photographs. Photographs worked well in the appreciation of overall aesthetic qualities such as the proportion of solid and void, while IVR improved the appreciation of the aesthetics of the details

more. On the other hand, the results indicate that the students can less appreciate façade details in photographs while they less appreciate colors in IVR. This highlights the need to consider how people perceive the different visual and aesthetic qualities in architecture both in normal realties and in IVR. The experiment also raises the attention that the present state of IVR technology is not fully helpful to appreciate color saturation and vibrancy. This is one of the well-known problems of this technology not only in architecture but also in other fields. İt is the challenge of future research to arrive at creative solutions for this problem. IVR thence will have a great potential in enhancing the abilities for appreciating the architectural aesthetics of design projects and of buildings alike.

The experiment also showed in its third part that the overall evaluation increases with higher levels of the students in an indication of the need to enhance the lower levels with better knowledge and understanding of aesthetics and IVR. This was supplemented in the final part by the agreement of all students on the importance of IVR for architectural education. The need for creative solutions for architects, educators, and students to have easy, simple, and cheap immersive engagement with the architectural space necessitates the search for immersive virtual reality technologies that can at least partially fulfill this goal.

Compliance with Ethical Standard

Conflict of Interests: The authors declare that for this article they have no actual, potential, or perceived conflict of interests.

Ethics Committee Approval: Ethics committee approval is not required for this study.

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