ASSESSING IMPACTS OF IMMERSIVE VIRTUAL REALITY BASED DESIGN REVIEWS ON LEARNERS' SELF-EFFICACY

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ABSTRACT: *An effective design review is critical to identifying changes and/or errors at the early stage of construction projects and reduce the project costs. Traditionally, design reviews are conducted by reviewing the project by reading multiple drawings. The inherent demands of reading project drawings are especially challenging for entry-level built environment learners who often need professional experience and may need more training and skills to fully understand technical representations. Previous research has focused on evaluating the impacts of interactive visualization technologies, such as virtual reality, on the learners' design review thinking skills and showed how such technologies could support learners and industry professionals in performing design reviews. However, such research has yet to assess its impacts on their self-efficacy in engaging in design review thinking skills. Self-efficacy can be defined as one's perception of their ability to perform a task, such as problem-solving and evaluation. To understand how the VR technology can support learners in increasing their self-efficacy in performing design reviews, the researchers hosted a pilot study to evaluate immersive virtual reality design reviews' impacts. Based on the results of this pilot study, the implementation of immersive virtual reality has the potential to positively impact first year-built environment learners' self-efficacy in performing design reviews.*

KEYWORDS: *Virtual Reality, Self-Efficacy, Motivation, Education, Built Environment, Design Review*

1. INTRODUCTION

Experimental learning through hand-on experience is key for the student to gain sufficient knowledge and skills about construction and built environment subjects. However, traditional teaching, which takes place in confined classrooms with occasional aid of online or web-based learning material (Fadol et al. 2018), cannot provide students with such experience. Inaccessibility to construction sites is a main challenge for experimental learning in the construction and built environment field (Ogunseiju et al. 2021). Over the past years, educators strived to use educational technologies to enhance the learning experience of the students. Virtual reality is one of these technologies that has drawn the attention of educators in different fields such as medicine (Duarte et al. 2020), Chemistry (Kader et al. 2020), and art (Serafin et al. 2016). Compared with traditional teaching, training using VR can stimulate students' interest in learning, and promote students' active learning while saving teaching costs and avoiding safety risks (Ding and Li 2022). VR-based learning can improve self-efficacy and motivation of the learners as it allows students to interact with a virtual environment resembling the actual environment and make experiments in a risk-free environment. Past studies showed the effectiveness of VR technologies for teaching different subjects in the Architecture, Engineering and Construction (AEC) industry such as infrastructure management (Arif 2021), earthquake-resistant construction (Kuncoro et al. 2023), offsite construction (Goulding et al. 2012) and safety (Le et al. 2015) (Le et al. 2014).

Design review is one of the critical tasks in the AEC industry because identification of design changes and/or errors at the early stage of construction projects can significantly reduce the project costs. This task requires the participation of various stakeholders and interpretation of multiple engineering drawings, which is often challenging for entry-level built environment learners who do not have professional experience. Therefore, they need training to fully understand technical representations in the drawings and gain pertinent skills in design review. VR-based learning has been used effectively for educating students in design review and enhance their thinking skills (Kandi et al. 2020). However, no research has assessed the impact of this approach on the self-efficacy of learners and engaging them in design review. To bridge this gap, this research aims to understand and evaluate how VR can support learners in increasing their self-efficacy in performing design reviews. To this end, a pilot study was conducted with students at the undergraduate level for teaching design review practices. The

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results of the study were then analysed, and the limitations of the research along with directions for future research are presented.

2. LITERATURE REVIEW

2.1. Immersive Virtual Reality in the Built Environment

Virtual Reality (VR) has several potential applications in many fields, including medicine, engineering, education, and entertainment (Hamad and Jia, 2022). VR could be defined as a technology that simulates an environment, which can be interacted with in a manner that appears real or tangible (Sanni Hafiz Oluwasola and Ayinde Munir 2015). The origins of VR technology can be traced back to the mid-1970s, with early experimenters using phrases like "artificial reality" to describe it (Machover and Tice 1994). The term "virtual reality" was coined by Jaron Lanier, founder of VPL Research, and the technology has since evolved from user interface design, flight and visual simulation, and telepresence technologies (Machover and Tice 1994). Freina and Ott (2015) identifies that there are two types of VR: immersive and non-immersive VR. Non-immersive VR is a computer-based environment that simulates places in the real or imagined world, while immersive VR gives the perception of being physically present in the non-physical world. Both types of VR are becoming more user-friendly and economically accessible (Kandi et al. 2020). Kaplan-Rakowski and Gruber (2019) further divided immersive VR (IVR) into low-immersion virtual environments (LiVR) and high-immersion three-dimensional spaces (HiVR). LiVR is a computer-generated three-dimensional virtual space experienced through standard audio-visual equipment, such as a desktop computer with a two-dimensional monitor. The ubiquitous online virtual world Second Life is an example of a LiVR environment. HiVR is defined as a computer-generated 360-degree virtual space that appears spatially realistic due to the high immersion afforded by a head-mounted device (Kaplan-Rakowski and Gruber 2019).

The technology has also undergone significant advancements in recent years, with new displays, input devices, and technologies being developed and introduced to the market (Anthes et al. 2016). VR has the capability to present spatial information in a more engaging manner, allowing for interaction with designed spaces at a human scale (Pacheco et al. 2014). Large screen size and wide field of view are key features of immersive VR systems, while texture, lights, shadows, and objects contribute to the overall VR experience. These VR attributes can further augment the richness of information and enhance the visualization process VR is being increasingly used in architecture, engineering, and construction to support experiential learning, movement through space and time, and interaction with the design (Sala 2013). VR enables a more qualitative representation of spaces from the users' perspective, creating the illusion of depth and immersion (Castronovo et al. 2013).

VR technology has the potential to impact the way users conventionally think and design the built environment promoting it beyond space and time constraints (Paranandi and Sarawgi 2002). The applications of the VR technology in Architecture, Engineering and Construction (AEC) industry are extensive, particularly in simulating environments and creating the feeling of immersion in a virtual world, which can assist architects and engineers in evaluating designs, understanding the needs of different users, especially those who are older or disabled. It can also promote inclusive design by providing in-depth insight into how particular groups of people experience the designed environment and how they interact with it. Nikolić and Whyte (2021) argue that VR can be used as a platform for an interdisciplinary integration of the allied design, social, and environmental disciplines. VR technology can provide easy-to-use communication solutions for all stakeholders in the AEC industry by providing a computer simulated environment with visual, auditory and haptic channels (Kähkönen 2003). VR technologies and computers are being utilized to facilitate the planning and construction of the built environment by aiding in the visualization and simulation of proposed designs, evaluating the visual impact of urban designs, and exploring broader economic ramifications (Whyte 2003). Tytarenko et al. (2023) reconstructed the Kilburun Fortress by monitoring the object's territory, analysing archival, librarian, and cartographic sources, and using various software tools such as AutoCAD, SketchUp, Quixel, and Twinmotion for modelling, rendering, and visualization. The resulting 3D model can be integrated into ArchiCAD and Revit software and showcases the applications of VR in the built environment. Although virtual reality environments (VRE) have enormous potential to engage students in classrooms and aid in construction workers' retention of safety knowledge, the adoption of VRE in the AEC industry remains minimal, as safety professionals still prefer hands-on training (Bhoir and Esmaeili 2015).

VR adoption faces several challenges in architecture and design, including a lack of integrated 3D databases and accurate reality models, technical limitations such as precise monitoring and remote sensors, and challenges in education such as the uniqueness effect, cybersickness, and accessibility (Fakahani et al. 2022). VR is also limited in its ability to create a real-life experience, particularly in conveying appropriate social behaviours and creating convincing virtual characters (Fakahani et al. 2022). Overcoming these challenges requires interdisciplinary efforts and finding the appropriate level of intervention (Fakahani et al. 2022; Hajirasouli et al. 2023; Lach et al. 2020; Zhang et al. 2020). Zhang et al. (2020) proposed future research directions on using the VR technology for the built environment, including user-centred adaptive design, attention-driven virtual reality information system, construction training system incorporating human factors, occupant-centred facility management, and industry adoption.

2.2. Immersive Virtual Reality in the Built Environment Education

Current practices in the built environment education often fall short of adequately preparing students for the complexities and challenges of real-world professional settings (Afacan 2023; Gardner 2022). Conventional teaching methods, which rely largely on textbooks and two-dimensional representations such as drawings and photographs, may fail to convey the multidimensional and dynamic nature of the built environment (Stewart and Baker, 2019). Students may therefore struggle to comprehend spatial relationships, scale, and materiality, limiting their comprehension of the built environment (Stewart and Baker, 2019). In addition, limited access to job sites and real-world initiatives hinders students' ability to gain hands-on experience and understand the practical implications of their decisions (Gibbons et al., 2021).

These limitations underscore the pressing need for innovative approaches that bridge the gap between theory and practice, equipping students with the necessary competencies to thrive in the complex-built environment. Consequently, situated learning is crucial to this field of study, as learning about the built environment requires exposure to a vast array of historical structures and design conditions (Afacan 2023) Situated learning in the built environment refers to an educational approach that emphasises learning within authentic and pertinent real-world contexts. It entails actively engaging students in tasks and challenges that replicate the complexities and requirements of their future professional roles (Bakhteyari et al., 2018; Aggerholm and Misfeldt, 2016). As a means of providing students with hands-on experience, conventional instructional methods utilise various case studies. Steele et al. (2023) assert that case studies are crucial for the education of those who are involved with the built environment. Thus, analysing completed projects allows students to examine the design process, construction techniques, and challenges faced by professionals, facilitating the development of problem-solving abilities and exposure to different design strategies (Hjaltadottir et al., 2018). However, when using case studies, the traditional teaching style encounters difficulties. To begin with, there are difficulties in comprehending projects through drawings and images, which limits students' grasp of spatial relationships, scale, and materiality (Stewart and Baker, 2019). Furthermore, limited access to job sites prevents students from firsthand experiencing the built environment, limiting their comprehension of project context and restrictions (Gibbons et al., 2021). Furthermore, student visits to construction sites are hampered by safety concerns, limiting exposure to construction processes and site-specific difficulties (Liu et al. 2019).

To address these challenges, the emergence of virtual reality (VR) technology holds promise in enhancing situated learning and overcoming the limitations of traditional methods (Elghaish et al. 2021). The advent of VR tools has enabled individuals to begin experimenting with and employing VR (Liu et al. 2019). According to Elghaish et al. (2021), VR is a revolutionary technology that has the potential to improve construction design processes as well as promote education in the built environment. VR provides an immersive platform that enables students to virtually explore case study projects in three dimensions. By experiencing projects from various perspectives, students gain a deeper understanding of spatial layout, scale, and design intent (Ho et al., 2018). VR simulations enhance visualization by offering realistic representations of projects, allowing students to interact with virtual elements and observe the dynamic behaviour of structures or building systems (Lee et al., 2020). Furthermore, VR in the built environment education can help researchers and students simulate real-life, potentially hazardous situations without exposing them to actual danger, making VR experimentations a credible approach for resolving construction clashes and defects (Afzal and Shafiq, 2021). Also, learners can efficiently investigate contextual dimensions associated with a building project using VR by adjusting specific parameters, making variable control simple to achieve (Xu and Zheng, 2020). Young et al. (2021) postulated that VR allows users to have an immersive experience of construction projects, so they can react effectively in real-world situations. Because participants in a lively, evolving situation can better try to remember safety knowledge, technological tools are also applicable in fields such as building risk assessments and safety training (Zhu and Li 2021).

Amidst the propagation of VR in the built environment, its maximum potential is yet to be realized (Safikhani et al. 2020), and there is a significant gap in VR involvement in the built environment between academia and industry (Delgado et al. 2020).

2.3. Self-Efficacy and Motivation

Self-efficacy is a belief in one's ability to perform well on a task and is a core concept of Social Cognitive Theory (Bandura 1997). Bandura (1997) indicated that self-efficacy is a key determinant of behavioural change, and psychological procedures can alter the level and strength of self-efficacy. Self-efficacy is an important factor in motivation, achievement, and accomplishment, and can be influenced by a variety of factors, including personality, motivation, and the task itself (Bandura 1997). Those with a high level of self-efficacy are not only more likely to succeed, but they are also more likely to bounce back and recover from failure (Resnick 2008).

Schunk (2011) describes how self-efficacy influences choice of activities, effort, persistence, and achievement, and how interventions involving models, goal setting, and feedback can affect self-efficacy. Eliyana et al. (2020) found that self-efficacy of entrepreneurial students influences achievement, and motivation significantly mediates the effect of self-efficacy on entrepreneurial achievement. Rodríguez et al. (2014) found that teachers with intermediate self-efficacy perception have more learning-oriented students than teachers with high self-efficacy, and students of teachers who are overconfident of their teaching capacity seem to engage less in studying to learn. Overall, self-efficacy is an important factor in motivating individuals to achieve their goals.

It is well documented that self-efficacy has a positive effect on motivation. Kanfer (1990) described motivation as the "psychological forces that determine the direction of a person's level of effort and a person's level of persistence in the face of obstacles". There are two types of motivation namely: extrinsic and intrinsic motivation (Schunk 2011). Ryan and Deci (2000) defined intrinsic motivation as the natural human propensity to learn and assimilate, while extrinsic motivation can either reflect external control or true self-regulation. Benabou and Tirole (2003) reconciles the economic view that individuals respond to incentives with the psychological view that rewards and punishments can undermine intrinsic motivation. Kuvaas et al. (2017) found that intrinsic motivation was associated with positive outcomes, while extrinsic motivation was negatively related or unrelated to positive outcomes. Overall, intrinsic motivation is driven by internal factors, while extrinsic motivation is driven by external factors, and that the two types of motivation can have different effects on outcomes.

Motivation is crucial in education and can fosters creativity and critical thinking as it cultivates resilience and self-assurance, and improves a student's agency (Schunk 2011). Motivation to learn provides direction, enthusiasm, and persistence in learning (Alfiah et al. 2021). Motivation is important for both students and teachers in achieving desired outcomes in education (Shrestha 2020). The theories of Maslow's hierarchy of needs and expectancy theory shed light on the fundamental aspects of motivation in the context of learning (Shrestha 2020). The application of various methods to motivate students and teachers is crucial and should be tailored to specific situations and requirements, as there is no universal approach (Shrestha 2020). The motivation of both teachers and students holds significance in ensuring an effective teaching and learning process within the field of education (Shrestha 2020).

Low motivation is associated with poor academic performance. Not being motivated was found to be associated with higher levels of stress and a lower Grade Point Average (Rücker 2012). Motivation is a key factor in effective school functioning and academic achievement (Halawah 2006). Fortier et al. (1995) proposed and tested a motivational model of school performance, which found that autonomous academic motivation positively influenced school performance.

Low motivation in education can be caused by various factors. Economic factors, low employment prospects, and educational background can contribute to low motivation in college students (Sahib, 2020). Intrinsic factors, such as a lack of interest in learning activities and embarrassment, can cause low motivation in elementary school students (Alfiah et al. 2021). A lack of interaction between teachers and students, as well as low reading ability, can contribute to low motivation in middle school students (Alfiah et al. 2021). O'Neil et al. (1995) found that offering financial incentives can increase student effort and improve test scores, suggesting that low motivation may be due to a lack of consequences or stakes attached to performance. Therefore, addressing factors such as economic status, interest in learning activities, teacher-student interaction, and incentives may help improve motivation in education.

Educators can increase students' motivation in the classroom by employing various strategies. Pahlavannezhad and Nejatiyan (2013) found that early knowledge of the course syllabus and assessment, rewards and positive reinforcement, and group work and role play can increase students' motivation to learn English. Brophy (2013) suggested that teachers can establish their classes as collaborative learning communities, support their students' confidence as learners, and help them appreciate curricular content as worth learning and applicable to their lives outside of school. Williams-Pierce (2011) identifies five key factors impacting student motivation: student, teacher, content, method/process, and environment, and provides suggestions from each area that can be used to motivate students. Mart (2011) suggested strategies such as providing a positive learning environment, using technology, and incorporating student interests to sustain students' classroom motivation.

Motivation has a positive impact on academic performance. Haider et al. (2015) found that both intrinsic and extrinsic motivation had a positive impact on students' academic performance. Goodman et al. (2011) found that intrinsic and extrinsic motivation were significantly related to academic performance, and that effort mediated this relationship. Afzal et al. (2010) also found that both intrinsic and extrinsic motivation had a positive impact on academic performance. Fortier et al. (1995) proposed and tested a motivational model of school performance, finding that perceived academic competence and perceived academic self-determination positively influenced autonomous academic motivation, which in turn had a positive impact on school performance. Overall, these papers suggest that motivation is an important factor in academic performance.

3. METHODOLOGY

3.1. Research Questions

As highlighted in the literature review, the implementation of immersive virtual reality (IVR) in built environment (BE) requires further research. New research efforts must investigate the impacts that the implementation of this technology has on learners' motivation, and specifically self-efficacy. Furthermore, as highlighted in section 3.2. research in the implementation of IVR in BE education necessitates investigations that leverage rigorous experimental methods. Based on this research gap, the researchers set out a goal of assessing the impacts that an IVR learning activity has on higher education learners in the BE discipline. Therefore, the research was concentrated on measuring the impacts of this activity on learners' self-efficacy and experience.

Based on these goals, the following research questions were posed:

1. Does performing design reviews with immersive virtual reality lead learners to have a higher self-efficacy?
2. Is the learners' experience positive whilst performing design reviews with immersive virtual reality?

Based on these research questions, two null hypotheses were considered. The first hypothesis was that the learners' reported average self-efficacy was going to be the same before and after the learning activity. Meanwhile, the second null hypothesis was that the learners' average experience was going to be neutral.

3.2. Experimental Design and Procedure

To test the hypotheses, the researchers designed a pilot study to test the early impacts of IVR. This pilot study was designed as a one group pre-test / post-test quasi-experiment to assess the impacts on learners' self-efficacy. This pilot study is considered a quasi-experiment due to the lack of randomized assignment to the treatment group. This method is not optimal for the generalization of the data and the impacts of the learning activity might be due to test learning. However, this method is acceptable for running pilot studies and assessing early impacts and identifying early trends (Knapp 2016).

In this pilot study the independent variable or treatment had only one level. This level was the learning activity designed to introduce first year BE learners to the concepts of design reviews while using IVR. The dependent variable measured for this pilot study was the learners' self-efficacy. The assessment instrument designed to measure the learners' self-efficacy is explained further in section 3.4. The procedure for this quasi-experiment can be seen in Figure 1. The participants were students and took part in this learning activity as part of their class time. The students had to participate in the activity; however, they were given the option not to participate in the pre and post-tests. A 10-minute pre-test was administered before the start of the activity. The same 10-minute test was administered as a post-test after the activity.

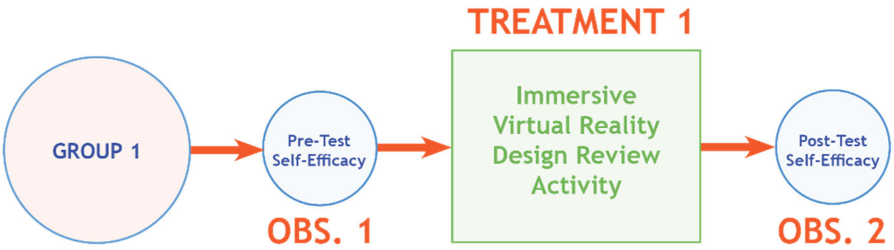

Figure 1. Quasi-experimental Procedure

After the pre-test the participants were provided with a tutorial on how to use the IVR head-mounted system. This tutorial allowed the participants to get familiar with the virtual environment and navigation controls. This tutorial lasted about 10 minutes. Participants that still had difficulty with the controls were provided with additional support and instruction. After the tutorial the participants were asked to navigate through a BIM model of a residential house and identify design mistakes. This residential house was designed in Autodesk Revit to have several design mistakes. The participants were paired in groups of two, where one was assigned the role of "driver" and the other of "note-taker". The driver would wear the headsets, which were casting its video output also to a desktop computer screen. The note-taker was tasked to write down design mistakes that the driver was identifying, on a sheet provided by the team. For every five design mistakes the participants had to switch roles. The total duration of the design review was set to be 30 minutes. This time limitation was also set to limit potential motion sickness of the participants.

3.3. Participants

The participants in the pilot study were first-year students enrolled in an Introduction to the Built Environment module at a university in the south of the United Kingdom. A total of 54 students were enrolled in the module and were asked to participate in the study. Ethical approval was received by the university ethic board to perform the study, and students were asked for consent to collect the data before administering the pre-test. As mentioned earlier, students that did not want to participate in the study were given the option of not answering the pre and post-test, but still had to participate in the class activity.

3.4. Equipment and Assessment instruments

The research team used twenty IVR headsets, the Meta Quest 2. This allowed a total of 40 students to participate in the activity. The video output of the headsets was cast on desktop computer screen over the Chrome web browser. To host the design review sessions the researchers used the IVR Arkio® software. Arkio allows users to host collocate in a virtual environment and perform design review sessions collaboratively. Learners were provided with virtual meeting rooms where the model of the residential house was preloaded.

The measured dependent variable was the participants' self-efficacy and experience. The pre-test was composed of ten questions. The questions were based on the "General Self-Efficacy Scale" (GSS) developed by Schwarzer & Jerusalem (1995). The questions from the GSS instrument were slightly changed to ask the participants about their perceived ability to perform design reviews. The post-test was composed of the same ten questions from the pre-test as well as an additional eleven questions to capture the learners' experience. These questions were based on the instrument developed by Boekaerts (2002), the OnLine Motivation Questionnaire. The participants were asked to indicate their agreement with the statements on a 5-point Likert scale. The questions for the pre and post-test can be found in Table 1.

Table 1. Pre and Post Tests Questions

Pre and Post Tests Self-Efficacy Questions	Post Test Participant Experience
1. How good do you think you are at reviewing design proposals?	11. How do you feel just after finishing the activity?
2. I am able to review most of the design proposals that I am presented with.	12. How easy was this activity?
3. When facing a difficult design proposal, I am certain that I can review it.	13. How well do you think you did in this activity?

4. In general, I think that I can successfully review most design proposals.	14. How useful do you consider this activity in learning about design reviews?
5. I believe I can succeed at reviewing most design proposals.	15. How important do you find it to do well on design reviews?
6. I am able to successfully review design proposals.	16. I felt the time used for the activity was beneficial.
7. I am confident that I can perform effectively design reviews.	17. I saw the value in the activity.
8. Compared to other people, I can do most review design proposals very well.	18. How enthusiastic were you about this activity?
9. Even when the design of a building is complex, I can review it quite well.	19. How pleasant did you find this activity?
10. How difficult did you find the topic of design reviews?	20. How much did you enjoy yourself during this activity?
	21. How much would you recommend this activity to your classmates?

4. RESULTS AND ANALYSIS

In this research, the research questions were answered by conducting two different types of statistical analyses. The first research question, which aimed to evaluate if the learning activity supported the participants in gaining higher self-efficacy, was tested by conducting a Paired-Sample T-Test. The second research question aimed at evaluating the participants' experience while participating in the activity. This question was evaluated by performing a One-Sample T-Test. This analysis aimed to test if the participants' experience was higher than neutral towards the positive. The tests were conducted using the statistics software package, IBM SPSS Statistics. A summary of the results can be found on Table 2 for the Pre and Post-Test, and on Table 3 for the participants' experience. While a total of 54 participants were recruited, only a total of 29 data points were used for the study as the rest either did not participate in activity or did not give permission to use the data.

Using the results from Table 2, a Paired-Sample T-Test was conducted to test if there was significant difference between the pre and post-test for the participants' self-efficacy. No outliers were detected that were more than 1.5 box-lengths from the edge of box in a box plot. Participants reported a higher self-efficacy after participating in the activity (3.890 ± 0.440) when compared to before the activity (3.190 ± 0.0.498), a statistically significant increase of 0.70 (95% CI, 0.885 to 0.536), $t(28) = 8.042$, $p < .0001$, $d = 1.493$. Therefore, the researchers confidently rejected the null hypothesis that the averages for the pre and post-test were going to be the same, as indicated by the significant difference and p value being below 0.0001. Furthermore, the effect size of the sample is quite large as indicated by the Cohen's D being 1.493 (Cohen 1988).

Using the results from Table 3, a One-Sample T-Test was conducted to test if the participants' experience was significantly different than neutral (Likert Scale value of 3). No outliers were detected that were more than 1.5 box-lengths from the edge of box in a box plot. The mean participants' experience score was significantly higher by 0.998 (0.95 CI, 0.7502 to 1.2205) than a neutral score of 3, $t(28) = 8.792$, $p < 0.0001$, $d = 0.606$. Therefore, the researchers confidently rejected the null hypothesis that the average for participants' experience was going to be neutral, as indicated by the significant difference and p value being below 0.0001. Furthermore, the effect size of the sample is between medium and large as indicated by the Cohen's D being 0.606 (Cohen 1988).

Table 2 – Pre and Post Test Average Answers

Question	Pre-Test Average	Post-Test Average
1. How good do you think you are at reviewing design proposals?	3.14	3.90
2. I am able to review most of the design proposals that I am presented with.	3.43	4.03
3. When facing a difficult design proposal, I am certain that I can review it.	2.90	3.79
4. In general, I think that I can successfully review most design proposals.	3.41	4.07
5. I believe I can succeed at reviewing most design proposals.	3.52	4.07
6. I am able to successfully review design proposals.	3.28	4.10
7. I am confident that I can perform effectively design reviews.	3.17	3.86

8. Compared to other people, I can do most review design proposals very well.	3.14	3.76
9. Even when the design of a building is complex, I can review it quite well.	2.97	3.69
10. How difficult did you find the topic of design reviews?	2.93	3.66
Self-Efficacy Average	3.190	3.890
Standard Deviation	0.498	0.440

Table 3 – Participants' Experience Average Answers

Question	Average
11. How do you feel just after finishing the activity?	
11.A How relieved do you feel after the activity?	3.62
11.B How at ease do you feel after the activity?	3.90
11.C How nervous do you feel after the activity?	2.97
11.D How satisfied do you feel after the activity?	4.14
11.E How worried do you feel after the activity?	3.38
11.F How confident do you feel after the activity?	3.90
11.G How concerned do you feel after the activity?	3.34
12. How easy was this activity?	3.97
13. How well do you think you did in this activity?	4.00
14. How useful do you consider this activity in learning about design reviews?	4.24
15. How important do you find it to do well on design reviews?	4.31
16. I felt the time used for the activity was beneficial.	4.31
17. I saw the value in the activity,	4.34
18. How enthusiastic were you about this activity?	4.07
19. How pleasant did you find this activity?	4.55
20. How much did you enjoy yourself during this activity?	4.45
21. How much would you recommend this activity to your classmates?	4.48
Participants' Experience Average	3.998
Standard Deviation	0.606

5. CONCLUSION

The ability to review and evaluate proposed design proposals is a key skill that BE learners must have once they graduate from their higher education institution. As discussed in the literature review, several studies have shown the positive impacts that IVR has on students' learning and their ability to meet learning objectives. However, the role of instructors is not just about meeting learning objectives, but it is also to support learners in developing their self-belief and confidence necessary to enter the industry.

This research conducted a pilot study to evaluate the effectiveness of using IVR in improving self-efficacy of students in engaging in design review thinking skills. The results and analysis have shown that, at a pilot study level, an IVR learning activity has potential in impacting students' self-efficacy while also being a positive experience. When looking at the first research question, the learning activity supported students in increasing their self-belief that they can perform design reviews while immersed in a virtual reality environment. This pilot study can give an early insight into what are the impacts that IVR has in the classroom beyond meeting learning objectives, supporting students in their confidence levels.

The next steps of this research efforts are to mitigate the limitations of sample size by recruiting a larger number of participants to support the researchers in scaling the findings and improving the generalization of the results. Additionally, one group pre-test / post-test quasi-experiments have experimental limitations and threats to internal and external validity. Therefore, the future research can include additional treatments to tackle the validity of the results. To address this limitation, the research has already started collecting the impacts a different medium, non-immersive VR, has on learners. By adding an additional treatment, a repeated-measure experiment and a two-way mixed ANOVA analysis can be conducted. To conclude, this study reports an initial result of an on-going research and the researchers will share further information on the research results in future publications.

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