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UTILISATION OF AUGMENTED REALITY FOR GENERATING ACTIVE LEARNING IN ARCHITECTURAL EDUCATION

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ABSTRACT

The advancement of Augmented Reality (AR) has impacted the world of architecture and has facilitated the construction industry to leap ahead, giving practitioners the ability to virtually visualize and spatialize design works with integration into the physical environment. Nevertheless, the utilization of the available visualization techniques in AR has not been widely used in the teaching and learning of architecture. Hence, this article aims to describe the exploration of utilizing AR in architectural education, as a method for generating active learning among students. This article also depicts case studies of the integration of AR visualization with architectural education by experimenting with techniques of AR application in the teaching and learning of building construction courses. Two (2) experimental projects were conducted with the substance of exploratory action research. The projects were carried out to experiment with the integration techniques and to assess the integration as attributes for successful learning. The two projects used a qualitative approach to have the exploratory inquiry of the experimentation, focusing on exploration of AR utilizations in two (2) building construction courses using steel and timber materials. This research shows that AR had been successfully utilized as the medium to disseminate architectural construction knowledge of both steel and timber construction materials. The experimentations also have inspired students to participate in the learning process actively and improved their cognitive learning capability.

Keywords: Augmented Reality, Architectural Education, Visualization, Immersive Environment, Design Education, Building Construction, Building Materials.

1.0 INTRODUCTION

The current advancement of digital technology has given birth to an enormous improvement in architectural visualization techniques. The techniques include visualization of two-dimensional drawings, three-dimensional digital models, virtual reality (VR), augmented reality (AR), mixed reality (MR) and extended reality (XR). In architectural practice, the advancements of immersive visualization techniques have assisted architects to model their designs with precision and detail (Gattupalli, 2024), so that convincing clients to realize their ideas could be done at ease. This immersive environment delivers a much more accurate representation of scale, depth, and spatial awareness that is incomparable to the conventional methods of rendering drawings and building scale models (Jullia Joson, 2022).

Specifically, augmented reality technologies have facilitated the construction industry to leap ahead, giving practitioners the ability to virtually visualize and spatialize design works with integration into the physical environment. This developing technology of AR has already impacted the world of architecture, design, and construction industry (James Wormald, 2023). The possible impact of AR technology on architectural education is also a matter of soaring pursuit. The last decade has shown increasing intellectual discourses, deliberating on the utilization of AR as one of the visualizing techniques to be adopted in architectural education. The demand keeps on increasing and the construction industry and job market command the necessity of utilizing AR for better equipped architects in the coming years (Jullia Joson, 2022). How architectural education might evolve in the future depends on how it incorporates the utilizations of this immersive technology.

Nevertheless, despite the immersive technological advancement, the utilization of the available visualization techniques has not been widely used in the teaching and learning of architecture. There is a substantial gap in expanding pedagogies and teaching methods that adopt the utilization of immersive technologies in the architecture and construction curricula (Hajirasouli, A. & Banihashemi, S., 2022). Hence, there is a necessity to explore the feasibility of integrating AR technology in tertiary education, especially in the fields that require visualization for their teaching and learning environments.

Hence, this article aims to describe the exploration of utilizing AR in architectural education, as a method for generating active learning among students in architectural education. This article depicts case studies of the integration of AR visualization with architectural education by experimenting with techniques of AR application in the teaching and learning of building construction courses. Two (2) projects were carried out to experiment with the integration techniques and to assess the integration as attributes for successful learning. The two projects used qualitative approaches to have the explorative inquiry of the experimentation, focusing on tentative usages of AR in two (2) building construction courses using steel and timber materials. Meanwhile, the quantitative research approach was also applied to the two projects by having survey questionnaires to obtain students' feedback on their acceptance of the integration.

2.0 LITERATURE REVIEW

2.1 Augmented Reality (AR)

Augmented Reality (AR) has an immense potential to produce spectacular architectural visualization and representation. Augmented reality is defined as the "emerging technology that allows the real-time blending of the digital information processed by a computer with information coming from the real world using suitable computer interfaces" (AR-media). The users could visualize "a composed world," mixing the real world with virtual objects (Redondo et al., 2013). Batchelor et al. (2021) describe the advancement of AR has also been widely used in locative AR games. Computer games become more attractive as AR lets virtual elements overlaid and integrated into the actual physical space. Hence, AR has a high potential to be utilized for the dissemination of Architectural Knowledge. Figures 1 and 2 show how visualization of a virtual object could be interfaced with a situated real world in real time, simply by using a simple tool like mobile telephone that traces a maker on a piece of paper. Meanwhile, figure 2 also shows how AR enables virtual and real objects seemingly co-exist at full scale.

Fig. 1: Overlays of virtual and real objects in AR interface

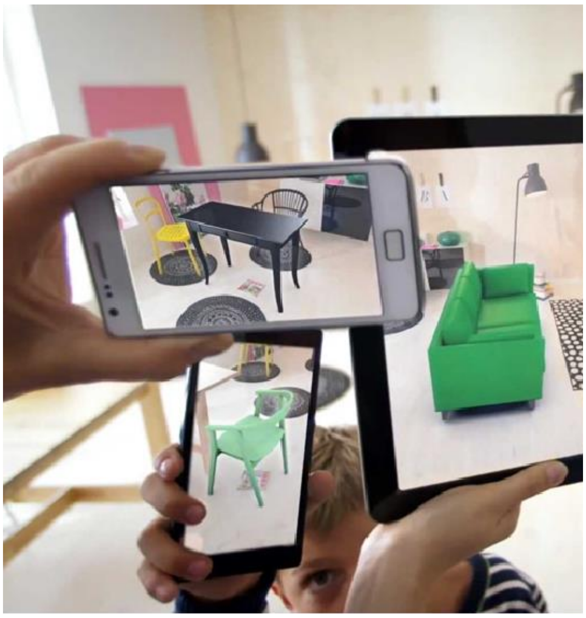

Fig. 2: AR enables the virtual and real objects seemingly co-existent at full scale

2.2 Challenging the Norm of Architectural Education

Architectural Education throughout the globe is dominantly accentuated on design studio. The architecture design studio (ADS) is a diverse environment that integrates theory with practice (Schon, 1987) that reflects experiential learning theory, specifically emphasizes "learning by doing" Kolb's (1984). This scenario of architecture design studio that combines experiential learning and iterative learning (Kolko, 2012), promotes active learning where knowledge is produced rather than disseminated. Furthermore, Jack Mezirow (2018) introduces the educational theory of "Transformative Learning" in architecture design studio, to reduce the hierarchical structure dominated by instructors that limit students' autonomy (A. M. Salama & Wilkinson, 2007). Formerly called student-centered learning, this pedagogical approach demonstrates how design instructors act as facilitators rather than authoritative figures, guiding students through complex design processes and encouraging the generation of new knowledge. Transformative learning involves a profound shift in the learners' perspectives, encouraging reflection, creativity, and critical thinking (Mezirow, 2018). This theory is particularly relevant for architectural design education, where design studios foster problem solving, reflective learning, and identity development.

Nonetheless, advanced pedagogic development with active instructional design implemented in architecture design studio generally has not been implemented in the teaching and learning of other architecture courses, such as building construction and architecture history classes. In non-studio courses, students routinely remain passive in class and have minimum engagement to the lesson learnt, resulting in ineffective learning outcomes. Hence, all architecture course courses should be converted into adaptive learning environments (Al Maani et al., 2021), where students develop resilience by adjusting to dynamic learning contexts. This recent Al Maani's pedagogical approach aligns with Mezirow's theory (2018) which emphasizes the importance of learners challenging their assumptions through problem-based engagement. This progressive shift required students and instructors to navigate uncertainty, reinforcing the transformative potential of learning through exploration and change.

Therefore, transforming the instructional design of non-studio architecture courses is inevitably critical to enhance architecture education in general. Specifically, this research has adaptability to the current learning theories, by exploring how utilization of AR could be a progressive method for generating active learning among students in building construction classes. This exploration of AR intends to make learning experience more enjoyable and effective. The implementation also encourages students' active participation with freedom and flexibility to create their own adaptive learning environment. Benzizoune (2024) ratifies that this learning development positively contributes to the quality of the learning through understanding and remembering the material in a more sophisticated way. Jiali, Ruixue, and Lu (2025) add that adaptive learning dynamically become more important because it caters to the differences in students' learning styles.

2.3 Augmented Reality in Architectural Education

AR technology offers a new way of delivering knowledge. In AR visualization, a virtual object interfaces with a situated real world in real-time (Azmin, et al., 2017). AR interfaces the real and virtual environment as it is a system that overlays, or augments, the real world with digital information that seemingly co-exists at full scale (Abboud, 2014). In architectural education, AR could enable students to virtually visualize design ideas which content information on spatial quality and materials used, while simultaneously experiencing the ideas in the real world (Gattupalli, 2024). The production of design hybrid realms in AR could minimize the gap between virtual and physical environments, giving students the opportunity to represent design ideas in more active and engaging ways.

For building construction and material courses, the usage of AR may offer a unique learning experience of building and construction details visualization. This visualizing tool enables students to envisage three-dimensional architectural design and comprehend construction details better than using traditional two-dimensional drawings. Scholars' works have also shown that the utilization of AR in architectural education contributes to numerous benefits (Bressler, et. al., 2013; Chen, et. al., 2016; Jullia Joson, 2022; Hajirasouli, A. & Banihashemi, S., 2022; James Wormald, 2023). AR stimulates learning by providing engaging, entertaining, cooperative, and interactive learning without jeopardizing learning achievement. AR also offers other key benefits in architectural visualization by increasing engagement among viewers, relishing immersive showcases, providing realism for virtual tours, and delivering alternative for data representation in architecture field.

3.0 METHODOLOGY

This research could be considered action research because the researchers directly involve in students' learning process. Action research has the "transformative power" (Dusty, 2024), to improve pedagogical instruction, to capture the potential of individuals and teams, and to execute meaningful change in educational endeavors. It demonstrates the interconnectedness of inquiry, teaching, and learning (Dusty, 2024) for the improvement of holistic understanding among stakeholders in education.

Adopting mixed-method approach, observation and survey questionnaires were two (2) main techniques used to describe the exploration of utilizing AR in two (2) projects designed for learning constructions and materials, in architectural education. The two projects used qualitative approaches to have the explorative inquiry of the experimentation, focusing on tentative usages of AR in two (2) building construction courses using steel and timber materials. Meanwhile, the quantitative research approach was also applied to the two projects by having survey questionnaires to obtain students' feedback on their acceptance of the integration.

The two (2) projects were conducted with the substance of exploratory action research. Researchers were involved in the experience of assessing the potential and effectiveness of integrating AR for the dissemination of architectural knowledge, explicitly focusing on steel and timber construction classes. The first project deals with the course of AAR 1195: Building Construction and Materials 2 (timber). The second project deals with the course of AAR 2198: Building Construction and Materials 3 (steel). For each project, there were three (3) similar steps involved. First, a literature review was conducted to examine the issues linked with current AR technology relevant to architectural education. Second, researchers experimented with integrating AR application in architectural education, and third, researchers sought participants' insights on the experimented projects.

3.1 Project 1: AAR 1195 Building Construction and Materials 2

This project investigated how an instructional design that had AR integration could be planned to make learning enjoyable. The learning content consisted of AR building models of 13 traditional Malay timber houses. Since the students who enrolled in the class were freshies, the educators had developed the content before the experiment. Upon completion of the teaching experiment, an online survey was distributed to students to get their feedback. Figure 3 shows how students actively engage in the learning process in a classroom environment, by using a television as a visualized tool. Meanwhile, figure 4 shows how students interactively control the visualization tools, using smaller gadgets such as mobile phones, to view the AR interface in an outdoor learning environment.

3.2 Project 2: AAR 2198 Building Construction and Materials 3

This project explored the teaching and learning of steel architectural construction with the integration of AR. An experiment of explorative learning was conducted to collaboratively construct 3-dimensional models of steel construction details of a building, using computer-aided (CAD) design software. Students then converted CAD virtual models into AR models and uploaded the AR models into an online database. Since the students were sophomores, they independently developed their learning content in AR models . Figure 5 shows a sample of an augmented construction detail, produced by a student for the class assignment. Whilst figure 6 shows a student interactively visualizing an augmented construction detail product by his peer, with the real time interface.

In both projects, students were asked almost the same questions, encompassing the same parameters of learning attributes of AR Integration; Enjoyability, Active learning, Understandability, and Effectiveness. Tables 1 and 2 show the parameters in relation to questions addressed to students. The survey questionnaires were formulated based on 1-5 Likert scale. Number (1) represents strongly disagree, number (2) represents disagree, number (3) represents the neutral opinion, number (4) represents agree, and number (5) represents strongly agree.

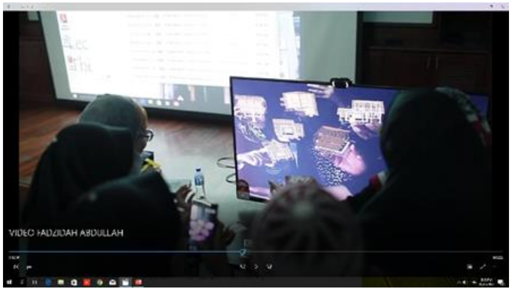

Fig. 3: Experiencing AR overlays in an indoor classroom environment (Project 1)

Fig. 4: Experiencing AR overlays in an outdoor learning environment (Project 1)

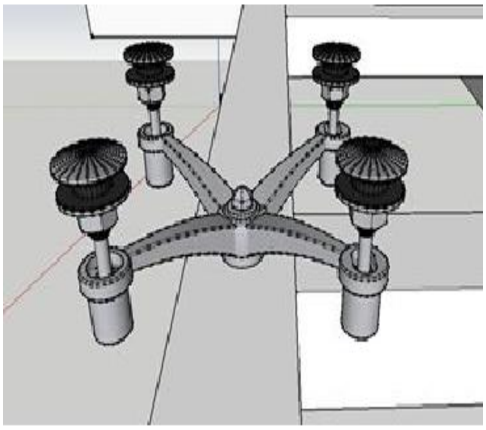

Fig. 5: A sample of an augmented steel construction detail, produced by a student (Project 2)

Fig. 6: A student is visualizing an augmented construction detail with real time interface (Project 2)

Table 1: Questions in Project 1, on the parameters of perceptions

No.	Parameters of Perception	Questions in Project 1
1	Enjoyability	Integration of AR makes learning Timber Construction Subject enjoyable.
2	Active learning	Integration of AR encourages students to ask more questions and actively be involved in classroom
3	Understandability	Integration of AR helps students understand Timber Construction easily
4	Effectiveness of the integration.	Integration of AR creates effective learning method for knowledge attainment on timber construction

Table 2: Questions in Project 2, on the parameters of perceptions

No.	Parameters of Perception	Questions in Project 2
1	Enjoyability	Exploration of AR Steel Structure Model is stimulating, with elements of sharing-meaning through social media interaction
2	Active learning	The project allows Interaction with the AR Steel Structure model to gain information
3	Understandability	Working on AR Steel Structure Model offers better understanding in learning steel construction as compared to listening to lectures
4	Effectiveness of the integration.	The project applies effective learning method to ensure understanding

4.0 RESULTS

This section shows the results of the survey questionnaire for both Project 1 and project 2.

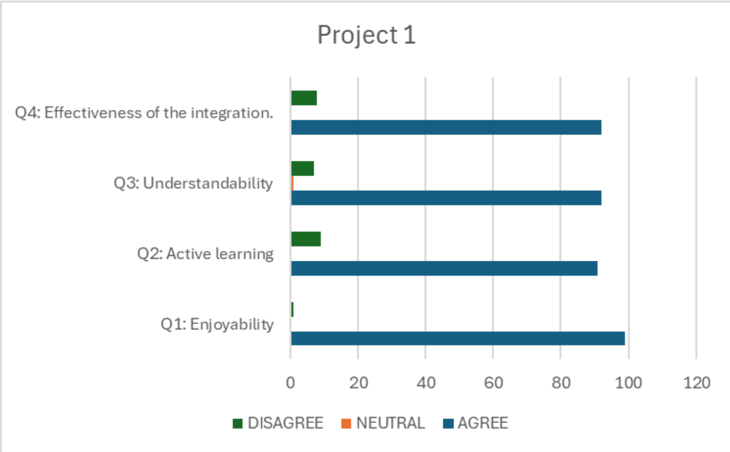

Fig. 7: The result of survey for Project 1

For Project 1, Ninety-two (92) students enrol in the class of AAR 1295: Building Construction and material 2, and 95% of the students participate in the online survey (n =87). The result of the study reveals that in Question Q1, 99% of the respondents agreed that AR makes learning Timber Construction Subject enjoyable. In Question Q2, 91% of the respondents agreed that AR encourages students to ask more questions and actively be involved in the classroom. In Question Q3, 92% of the respondents perceived that AR helps students understand Timber Construction easily, and in Question Q4, 92% of the respondents confirmed that AR creates effective learning method for knowledge. Fig. 7 displays the graphic representation of the survey results.

Most respondents confirmed that with the integration of AR, learning is favoured by very high percentage, due to its capability to make learning enjoyable, encourage active involvement of students, help students to understand subject learned easily and create effective learning for them.

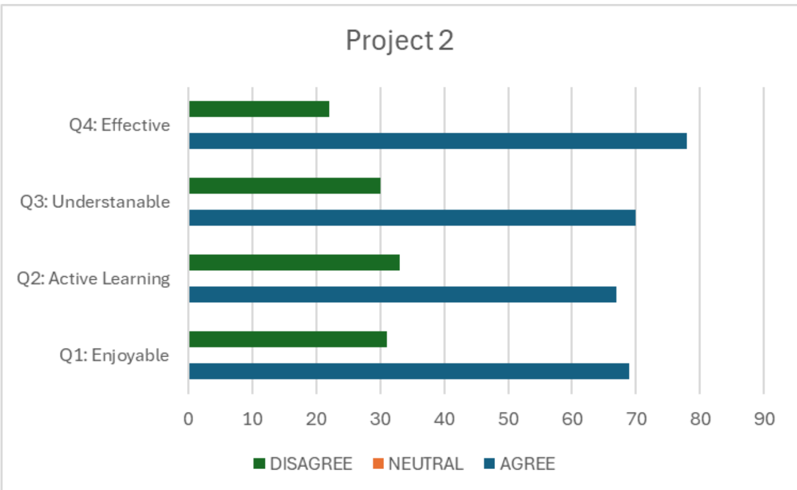

Fig. 8: The result of survey for Project 2

For Project 2, the results show that in Q1, 69% of the participants agreed that exploration of AR Steel Structure Model is stimulating (enjoyable), with elements of sharing-meaning through social media interaction. In Q2, 67% participants agree that project allows active interaction with the AR Steel Structure model to gain information. In Q3, 70% of participants think that working on the reconstruction of AR steel structure model offers better understanding as compared to merely listening to lectures alone. The project applies effective learning method to ensure understanding. The highest percentage of agreement satisfaction befell in Q4, where 78% of the respondents agree that the project applies effective learning method to ensure students understand the subject learned. Fig. 8 portrays the findings of Project 2.

Based on the analysis, it is concluded that most of the respondents agree that implementation of BL with integration of AR visualization has shown the potential to make learning stimulating, allow active interaction, offers better understanding, and initiate effective learning.

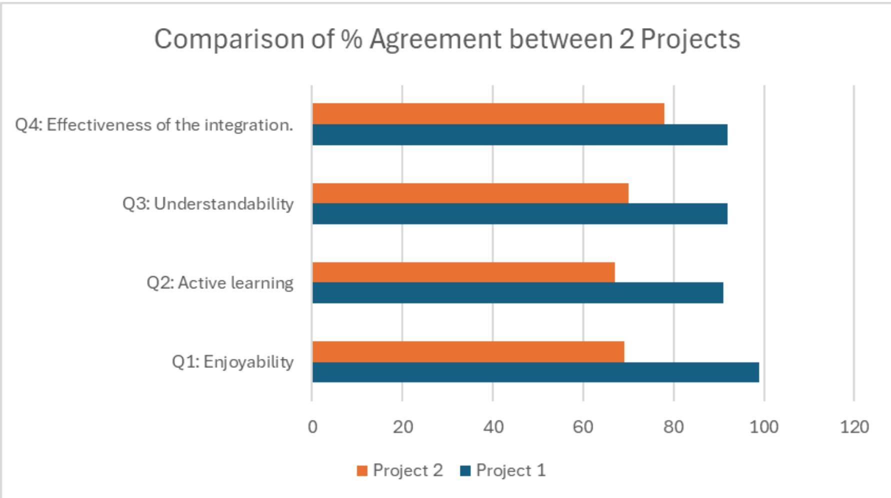

Fig. 9: Comparison of Survey Result for Project 1 and Project 2

Fig. 9 shows a comparison of the results of project 1 and project 2. Both projects had successfully integrated AR visualization in architectural education. The projects had four (4) parameters: enjoyability, active learning, understandability, and effectiveness of integration. In all categories of assessment, Project 1 had shown higher scores as compared to project 2. This scenario reveals that the freshies favored the integration AR visualization better as compared to the sophomores.

The following are possible justifications for the significant findings. Students who undertook Projects 1 experiments were fresh to accept any new method of teaching and learning compared to their second-year counterparts. The sophomores' group have had exposure to various instructional designs throughout their two years of study on campus and introducing them to another new one has fashioned no surprise.

Second, students who participated in Project 1 did not prepare the learning content themselves because educators had meticulous preparation for the experiment. Hence, students did not experience the burden of looking for teaching materials and the problem of constructing learning content. In Project 2, students had to prepare the learning content by themselves. Hence, the extra workload given to the sophomore group influenced their perception of the experiment. Nevertheless, since the percentage differences are minimal, it is concluded that the integration of AR visualization in architectural education positively impacts students.

In all categories of assessment, Project 1 has shown higher scores as compared to project 2. This scenario reveals that the freshies favor the integration of AR visualization in construction subjects better as compared to the sophomores.

5.0 CONCLUSION

This research has successfully assessed the integration of AR visualization in architectural education, by experimenting with techniques of AR application in the teaching and learning of building construction courses. This research found that AR had been successfully utilized as the medium to disseminate architectural construction knowledge of both steel and timber construction materials. AR could be perceived as an educational tool that encouraged interaction among students during the learning process. The AR 3-dimensional visualizing tool inspired students to participate in the learning process actively and improved their cognitive learning capability.

Based on this research, it could be reflected that architecture students are ready for transformational frameworks of teaching and learning, with the integration of the usage of AR. With the verge of advanced immersive environment and AI advancement, a better learning environment could be empowered for the future students.

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