

Creating Spatial Experiences Using Virtual Reality Applications in Architectural Design: Insights from the Design Studios in Malaysia

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Abstract

This article explores the transformative impact of virtual reality (VR) technology on architectural education, within the context of the design. It delves into the dynamic relationship between VR technology, e-learning, and design education, shedding light on the positive outcomes arising from their integration. Since VR technology rapidly advances, traditional educational approaches are shifting the paradigm, ushering in innovative pedagogical methods that empower students to navigate complex concepts through digital tools.

The research employs interviews as a methodology. It conducts interviews with two educators and a focus group discussion with ten students at the International Islamic University Malaysia. It scrutinizes the pedagogical design of VR within the educational settings.

The findings contribute valuable insights into the evolving landscape of architectural education influenced by cutting-edge technologies.

Keywords: Virtual Reality (VR), Architectural Education, Thematic Analysis, Technology Acceptance Model (TAM), Design Process, Collaboration.

Introduction: The Background

Technological advancements have permeated all aspects of modern life, significantly transforming how knowledge is acquired and disseminated (Neuberger et al., 2023). In an era defined by rapid technological improvements where education is expanding, Malaysia's Education Blueprint 2013-2025 highlight the significance of integrating technology into the classroom to enhance learning outcomes and develop 21st-century skills (Karawani & Preece, 2022; Shan et al., 2016). In fact, the landscape of education is experiencing a profound transformation. In education, this technological evolution has given rise to e-learning in traditional curricula, which has paved the way for new and innovative pedagogical approaches. These approaches leverage digital tools and platforms to revolutionize traditional pedagogical methods (Karawani & Preece, 2023; Oke & Fernandes, 2020). The Blueprint outlines methods and approaches to foster technology that assists the rich learning environment by increasing access to digital learning platforms, improving teachers' digital competencies, and facilitating flexible learning pathways (Aroff, 2014). Within the discipline of architecture, this

transformative potential offers an unparalleled opportunity for students to explore intricate design concepts and unleash their creative capacities.

Virtual reality technology is a rapidly developing form of information technology. It serves as a novel means of conveying knowledge and a cognitive tool, enabling learners to mentally reconstruct their existing knowledge frameworks (Raja & Priya, 2021). By integrating virtual reality technology into the realm of education, students not only gain immersive experiences within lifelike virtual environments but also enable educators to utilize digital-age thinking methods in their instructional practices (Jiang et al., 2018).

Wright et al. (2020) show that e-learning has disrupted conventional educational paradigms, allowing for innovative and immersive learning experience. In the context of architecture, this shift holds a great promise for reimagining how students engage with the design process and collaborate on architectural projects. In fact, by incorporating digital tools and virtual environments, architecture students can transcend the constraints of traditional mediums, unlocking new avenues for creativity and exploration. As Ali (2020) says, in the light of the rapidly evolving technological landscape, conventional educational approaches face the need for adaptation and evolution. Embracing e-learning within architectural curricula empowers students to envision, analyze, and refine their design concepts with unprecedented depth and interactivity. In this context, the immersive experiences of virtual reality (VR) and the precision of 3D modeling software enable the students to profoundly understand spatial relationships, lighting effects, and materiality in their architectural designs (Venkatesan et al., 2021).

However, while VR technology brings opportunities, it also presents challenges that must be addressed to fully harness its potential in architectural education (Hernandez-de-Menendez et al., 2021). Educators, students, and institutions may encounter resistance to change, fearing the loss of tangible, hands-on experiences that have been fundamental to architectural learning for generations (Pelletier et al., 2022). Overcoming this resistance requires a thoughtful approach to illustrate the transformative power of VR technology without compromising the essence of architectural pedagogy. Moreover, the availability and accessibility of VR technology infrastructure pose additional hurdles to successful integration (Mampane, 2020; Nassr et al., 2021). Indeed, ensuring equitable access to digital tools and platforms is crucial to avoid perpetuating disparities among the students based on socio-economic backgrounds. Strategic planning and investment are required to bridge the digital divide and create an inclusive learning environment that empowers all aspiring architects (Pelletier et al., 2022). Moreover, the availability and accessibility of VR technology infrastructure pose additional hurdles to successful integration. Ensuring equitable access to digital tools and platforms is crucial to avoid perpetuating disparities among the students based on socio-economic backgrounds. Strategic planning and investment are required to bridge the digital divide and create an inclusive learning environment that empowers all aspiring architects (Sanders & Scanlon, 2021).

Moreover, adapting traditional curriculum structures to leverage e-learning tools fully presents a multifaceted challenge (Matthew et al., 2021). Without question, redefining instructional methodologies, assessments, and collaborative practices is essential in creating a seamless fusion between the digital realm and the fundamental principles of architectural education. Needless to say, collaborative virtual design reviews and cross-border design charrettes illustrate the potential for enhanced collaboration and global connectivity (Kempenaar, 2017).

The Issue

According to Chavarría-Bolaños et al. (2020), integrating VR technology-enhanced e-learning into architecture curricula faces significant challenges that address several issues with the current curriculum. The effectiveness of the traditional curriculum in providing basic knowledge limits the student's ability to be involved in an immersive experience, which is regarded as critical for architectural design (Maghool et al., 2018). VR can transform this by allowing students to visualize and interact with 3D spaces, providing a more comprehensive

understanding of scale, structure, and spatial relationship elements that are difficult to grasp through 2D drawings and models fully (Farouk et al., 2024). However, the current curriculum heavily relies on traditional pedagogical practices, where the belief persists that full comprehension of architectural design can only be achieved through these conventional methods (Karawani & Preece, 2022). This has resulted in resistance to adopting new technologies like VR, as educators and institutions are reluctant to shift from long-standing teaching models (Adams et al., 2018; Jan et al., 2020). Moreover, integrating VR into architecture education poses unique challenges due to the hands-on nature of the subject. Architecture involves not only theoretical learning but also physical model-making and design processes, which some fear may be undermined by over-reliance on virtual simulations (Durmuş & Günaydın, 2023). There are concerns that these digital tools could dilute the tactile, material understanding critical to architectural practice.

Moreover, there are significant infrastructure and accessibility issues. The lack of adequate VR technology in many institutions creates a digital divide, preventing some students from fully engaging with this immersive technology (Anafo et al., 2020). Educators also face the challenge of staying updated with rapidly evolving IT tools, which demands continuous professional development to ensure that they can integrate VR effectively into their teaching (Collins & Halverson, 2018; Morgan, 2020). Incorporating VR also raises concerns about the loss of human connection and critical engagement inherent in the traditional classrooms. Redefining curricula, instructional methods, and assessment techniques to include VR without losing these key elements of architecture education presents another major obstacle (Arranz-Paraíso & Arranz-Paraíso, 2024). In this context, this paper examines these challenges and explores strategies to overcome them, in order to ensure that VR technology is effectively integrated into architectural education.

This article aims to explore how integrating Virtual Reality (VR) into e-learning can transform architecture education, particularly in design courses. Its objectives are:

1. To identify the key challenges associated with integrating VR technology into architecture curricula, particularly focusing on the resistance to change from traditional teaching methods and the limitations of the current infrastructure.
2. To explore effective strategies for incorporating VR technology into architectural education to enhance immersive learning experiences while addressing concerns about the impact on hands-on model-making and tactile learning.
3. To provide recommendations for educators and institutions to overcome barriers such as technological accessibility, professional development needs, and curriculum redesign, ensuring that the integration of VR maximizes its potential benefits in architectural education.

Therefore, it poses the following research questions

1. What are the key challenges and obstacles faced when integrating VR technology into architecture curricula, particularly regarding resistance to traditional teaching methods and infrastructure limitations?
2. What strategies can effectively integrate VR technology into architectural education while maintaining essential hands-on learning experiences, such as model-making and tactile engagement?
3. How can educators and institutions overcome barriers like technological accessibility, professional development, and curriculum redesign to maximize the benefits of VR technology in architectural education?

By reviewing current research, conducting interviews with educators and students, and analyzing both studies and interview feedback, the paper will provide insights into the potentials of VR to enhance learning. It addresses the limitations of traditional teaching methods, which often lack the immersive experience crucial for understanding architectural design. The research explores the practical strategies to overcome resistance to adopting new technologies, concerns about losing hands-on learning, and infrastructure challenges in many

institutions. Ultimately, this article highlights how VR can enhance creativity, collaboration, and adaptability in architectural education, offering students a more comprehensive understanding of design elements like scale and spatial relationships, while preparing them to embrace innovative approaches in shaping the future of the built environment.

Theoretical Framework

This theoretical framework establishes a structured foundation guiding the design, data collection, analysis, and interpretation of conclusions of this paper. By integrating VR technology-enhanced e-learning into architectural education, particularly in design courses, the framework supports examining how immersive technologies can enhance the learning process. The Technology Acceptance Model (TAM) is adopted as the core theoretical foundation (design subject) to explore this integration.

Technology Acceptance Model (TAM)

Originally proposed by Davis in 1989, the Technology Acceptance Model (TAM) (as illustrated in the Fig. 1) serves as a valuable framework for understanding the factors that influence users' acceptance and adoption of new technologies (Davis, 1989; Granić & Marangunić, 2019). This model highlights two primary factors that drive technology adoption: perceived ease of use and perceived usefulness, with ease of use being particularly influential in encouraging individuals to embrace new technologies (Ping & Liu, 2020). These core elements are critical when evaluating how VR technology can be successfully integrated into the curriculum of architectural education. The selection of TAM for this study is justified due to its established effectiveness in analyzing technology adoption across various fields, including education (Rafique et al., 2020).

Moreover, TAM is particularly useful in this research because it helps explain the factors that affect willingness of the educators and the students to embrace VR technology in their teaching and learning processes (Masrom, 2007; Ndebele & Mbodila, 2022). This model aligns with the research problem, identifying resistance to new technologies, such as VR, within the traditional pedagogical settings. By applying TAM, the study can delve deeper into how perceptions of the educators and the students as well as the ease of use and usefulness of VR influence their acceptance of it as a transformative tool in architectural design education. Furthermore, the contribution of TAM to the thematic analysis of this study is significant. It offers a structured lens through which the barriers and enablers to VR adoption can be identified and categorized (Huda et al., 2024). The thematic analysis focuses on key themes derived from TAM, such as the ease of use of the technology, usefulness, and resistance to change. By applying TAM within the thematic framework, the research can systematically assess the challenges and opportunities presented by VR technology in architectural education, thus providing a clear path to developing effective strategies for overcoming the identified obstacles (Wu & Chen, 2017).

In this context, TAM is relevant for understanding the general acceptance of VR in architecture education and providing a comprehensive analysis of the factors that can facilitate or hinder the successful integration of VR technology-enhanced e-learning within architectural curricula. Through the lens of TAM, this study bridges the gap in existing literature by identifying practical insights that educators can apply to promote wider adoption of VR in their teaching practices.

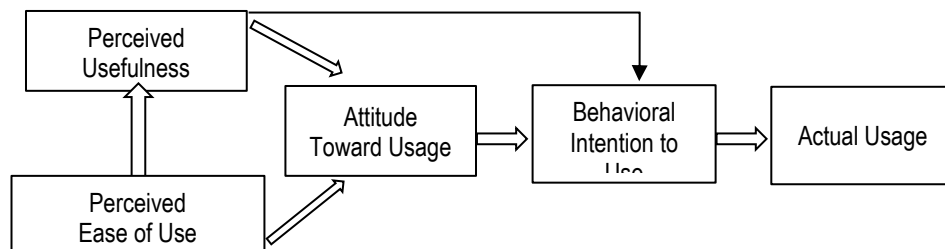


Fig. 1: Technology Acceptance Model (TAM)

Source: Davis, 1989

Literature Review

A comprehensive literature review was conducted to gather existing qualitative research, academic articles, and relevant publications related to VR technology integration in architectural education. This literature review provides a foundation for understanding the key themes, challenges, and best practices in the field, enabling the development of focused research questions.

VR Technology Integration in Architectural Education

The integration of VR technology refers to incorporating advanced digital tools, software, and other VR technological advancements in the teaching and learning of architecture (Amin, 2023). This integration aims to enhance the learning experience of the students and improve their skills in terms of design, visualization, and communication. With the rapid advancement of VR technology, its integration in architectural education has become increasingly important to prepare students for the demands of the new learning method to stay competitive in global education (Baydoun et al., 2024; Meyer & Norman, 2020).

The construction industry, which has traditionally been dependent on craft skills (Wijethunga et al., 2024), is now modified to be one based on the synthesis of information and VR technology. Recent advancements in construction speed and cost have demonstrated the value of an integrated team-based strategy. Now that the market will dictate such fundamental changes, people in charge of education will have no choice but to modify how architects and engineers are educated (Baydoun et al., 2023; Nicol & Pilling, 2000).

Knowledge Content Transformations

Several transformations are being witnessed as a reaction to several transformations or paradigm shifts. Three knowledge content areas are emerging to reflect continuous shifts in knowledge content. According to Salama (2007), these are the Environment Behavior Studies (EBS), Sustainability and Environmental Consciousness Studies, and Digital Technologies or virtual practices.

Digital Technology or Virtual Practice

This knowledge content transformation uses either digital technology or virtual practice. The development of telecommunication technologies has advanced recently. Architectural education and practice are changing as a result of digital technologies and design in virtual worlds (Clark-Wilson et al., 2020; Kugurakova et al., 2021; Sepasgozar, 2020). The design studio, the core of architectural education, is being reconfigured as a result of developments in electronic design and communication (Masd u & Fuses, 2017). Early studies that illustrate this paradigmatic trend have been carried out by eminent academics (Alvarado & Maver, 1999; Megahed & Hassan, 2022; Nyka et al., 2020). They have tried to integrate virtual design practices into studio teaching in addition to including computer-aided design (CAD) courses in architecture curricula. Virtual realities in studio instruction have been made possible by the advancements in CAD, visualization, and digital modelling along with cutting-edge technologies to communicate data, visuals, and life-action design experiences (Fay, 2020).

Students and Virtual Reality

In fact, students are no longer required to convene in a single physical location and timeframe to collaborate on a common design challenge. In virtual settings, critics can offer feedback through the Internet or email, and jury members can virtually assess architectural students without the need to be physically present in the same room (Alnusairat et al., 2021; Megahed & Hassan, 2022;  algamc ođlu & Gen , 2021). This indicates a shift in the traditional studio approach as computers are being employed to facilitate these communications. Consequently, the conventional studio arrangement is being transformed through the integration of computers and telecommunication technologies, enabling participants to connect across different geographies, cultures, and regions (Pavlik, 2021). While this trend emerged in

the mid-1990s, it is anticipated that its influence on architectural education will be significantly profound in the upcoming years (Dreifuss-Serrano & Schreier-Barreto, 2021; Hensh et al., 2021).

Research Methodology

This article adopts a qualitative research approach to explore the integration of VR technology-enhanced e-learning curricula in architecture education in terms of design courses. The study primarily focuses on how students can accept and engage with VR technology in their architectural education, especially in design subjects, by understanding the subjective experiences, perceptions, and perspectives of educators and students who were involved in this process.

Research Design

To address the research objectives, semi-structured interviews and focus group discussions were selected as the primary methods for data collection. These methods are appropriate for gaining deep insights into the subjective experiences and perceptions of the participants allowing for a more nuanced exploration of the integration process.

Interviews

Qualitative data were collected through semi-structured interviews with two educators and focus group discussions with 10 students in the Architecture Faculty at International Islamic University Malaysia (IIUM). The interviews and group discussions delved into their experiences, perceptions, and practices related to integrating technology into architectural education. Open-ended questions were used to encourage the two instructors to express their thoughts and provide detailed insights into the challenges and strategies involved in the integration process. The interview and group discussion questions consisted of 10 questions extracted from the objectives of this article.

Recruitment Process

Participants were invited using a purposive sampling method, and lecturers and students were requested to participate through formal emails sent by the faculty. Before participating, all individuals were notified about the objectives of the study, and it was highlighted that their involvement was voluntary and would not influence their academic results. Consent was obtained before the interviews and focus group discussions commenced.

Participants

The study involved a group of students and lecturers teaching architecture education. Semi-structured interviews were conducted with two educators who teach design subjects and ten students who are learning the same subject with the aim of gaining a better understanding of how VR technology can be utilized to integrate e-learning in architectural education (design subject). The sample size was sufficient for qualitative research, providing a balance of perspectives while ensuring data saturation.

Data Collection

The semi-structured interviews and focus group discussions were conducted face-to-face and in virtual meetings, depending on participant availability and preferences. The interviews, which included 10 open-ended questions, were designed to align with the research objectives and the Technology Acceptance Model (TAM) framework, providing a comprehensive exploration of the integration of VR technology. The focus group discussions motivated student interactions, allowing for collective insights into shared experiences and challenges.

Data Analysis

The data collected from the interviews and focus group discussions were analyzed using thematic analysis. This process involved transcribing the data, coding responses, and identifying recurrent themes related to the benefits and challenges of integrating VR into architectural education. The Figure 2 illustrates the thematic analysis process, although it requires proper citations in line with the appropriate sources.

The study ensured the trustworthiness of the findings through triangulation, where data from the interviews and focus groups were cross-referenced with existing literature to validate emerging themes. This process, shown in the Figure 3 highlights the steps taken to ensure the credibility and reliability of the findings (Bans-Akutey & Tiimub, 2021; Noble & Heale, 2019; Natow, 2020). Moreover, researcher reflexivity was maintained throughout the analysis, ensuring that personal biases did not influence the interpretation of the data.

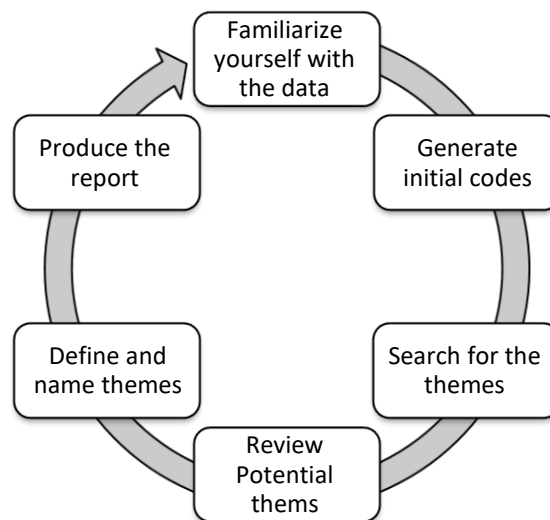


Fig. 2: The Thematic Analysis to come up with the Findings
Source: (Neuendorf, 2018)

Triangulation

The accuracy and validity of the findings were improved by utilized triangulation in this article through cross-referencing the interview and group discussion data with the literature review (Bans-Akutey & Tiimub, 2021; Noble & Heale, 2019). This triangulation assisted in validating and strengthening the qualitative findings by exploring shared aims and differences between the existing literature and the interview data (Donkoh & Mensah, 2023; Natow, 2020). Moreover, this cross-referencing ensured that the findings were grounded in multiple data sources, strengthening the overall conclusions (Meydan & Akkaş, 2024). The Figure 3, which demonstrates the triangulation process, has been revised for clarity, especially regarding the central elements of the diagram; hence, the Figure 3 illustrates the process to validate the findings (Tzagkarakis & Kritas, 2023).

Moreover, the Figure 3 illustrates the triangulation process employed to validate and strengthen the study's qualitative findings. The triangulation method is used to cross-reference different data sources to ensure the reliability and credibility of the results (Stamenkov, 2023).

In this context, triangulation involves the combination of three distinct data sets:

- **Interview Data:** qualitative data was collected from semi-structured interviews with architecture educators.
- **Focus Group Data:** feedback and insights from group discussions with architecture students.
- **Existing Literature:** information gathered from prior research studies and theoretical frameworks on integrating VR technology in education.

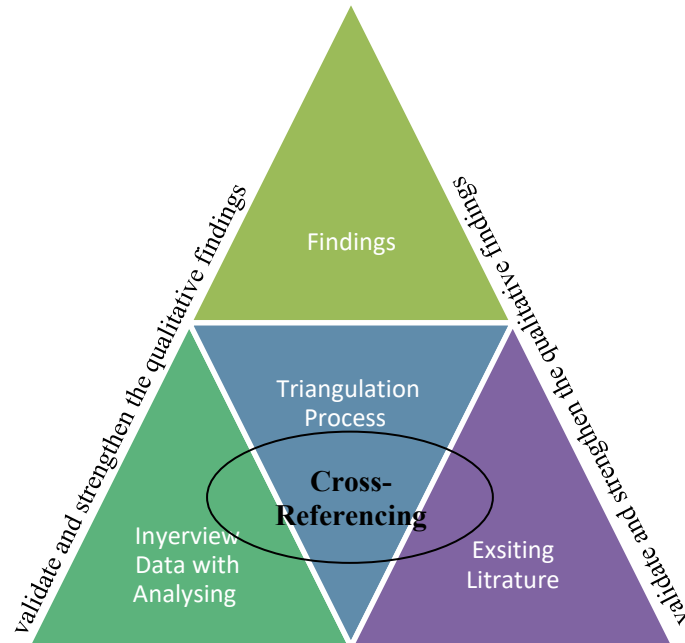


Fig. 3: The Triangulation Process to validate the Findings
 Source: Tzagkarakis & Kritas, 2023

These three data sources are cross-referenced and analyzed together in the central analysis stage. In this stage, patterns and themes are identified, compared, and validated. The purpose of this step is to ensure that the insights from the interviews and the focus groups align with or challenge the findings of the existing literature. This process not only strengthens the credibility of the study but also identifies unique or novel perspectives that may emerge from the qualitative data. The text in the center of the diagram originally reads, "validate and strengthen the qualitative findings," which represents the function of triangulation. However, to more accurately reflect the process, the text has been revised to "Cross-reference and synthesize insights from interviews, focus groups, and literature to validate findings." This revision clarifies that triangulation involves not only validation but also the synthesis of multiple data sources to develop a comprehensive understanding of the integration of VR technology in architectural education.

Results

The analysis concentrates on describing the process of thematic analysis used in the study, including the steps taken to identify, code, and analyze themes from the semi-structured interviews with two educators and group discussions with 10 students' transcripts. The Table 1 below explains the method used to come up with the themes and the findings.

Table 1: The Process of The Thematic Approach Analyzing
 Source: Author

No	Transcribe	Code	Categories	Potential Themes	Theme name	Result
1	Using VR technology in our architectural studies has been amazing. We can walk through our designs like they're real, and it helps us work together with	Amazing We can walk through our designs. like they're real	Perceived Benefits	Amazing walk through our designs. like real work together.	Enhanced Design Exploration Enhanced Visualization Enhanced Collaboration	Design Exploration Visualization Collaboration

	classmates from anywhere, making our learning and future designs even better	helps us work together. learn anywhere and everywhere		learn anywhere and everywhere		
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The transformation of traditional education to the virtual reality learning method VR led to the existence of five important themes. The figure below clarifies the five themes' appearance after coding the interviews.

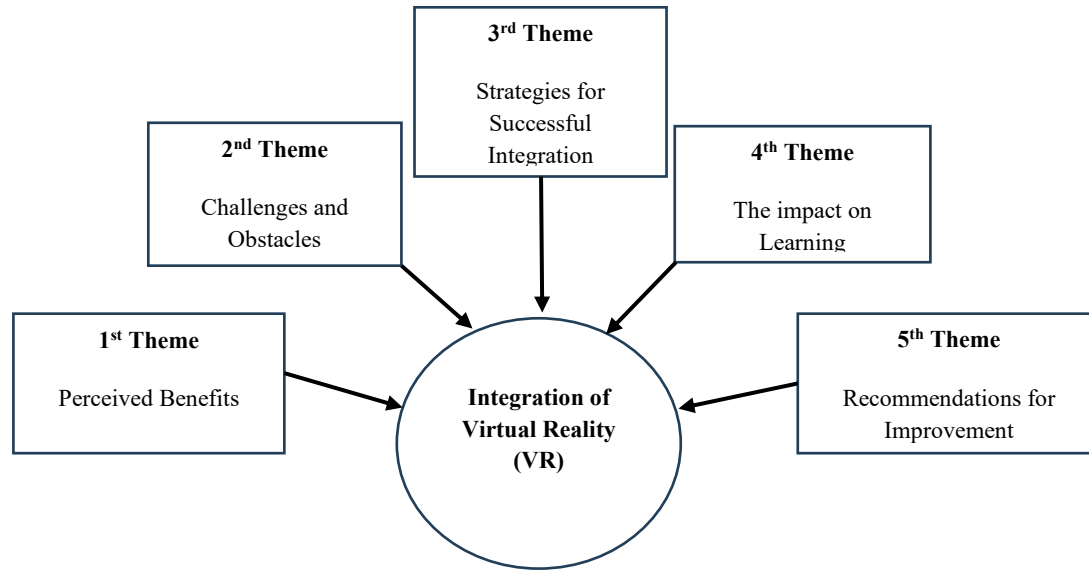


Fig. 4: The Themes of Integration Virtual Reality VR
Source: Author

Theme 1- Perceived Benefits of VR Technology Integration

The first theme of the study focused on the perceived benefits of integrating VR technology in architecture education (design subject). Participants, including educators and students, highlighted several advantages of VR technology integration.

Respondent 1 says:

" Using VR technology in our architectural studies (design subject) has been amazing. We can walk through our designs like they're real, and it helps us work together with classmates from anywhere, making our learning and future designs even better".

Respondent 2 says:

"VR has completely transformed how we approach architectural design. The ability to immerse ourselves in virtual spaces allows us to experience and understand our designs in ways that were not possible before. This technology has enhanced collaboration, enabling us to work seamlessly with peers and educators, no matter where we are."

Respondent 3 says:

"With VR, we're no longer limited to 2D drawings or models. We can step into our designs, explore them as if they were built, and make real-time

adjustments. This has significantly improved our understanding of spatial relationships and design concepts."

Respondent 4 says:

"The integration of VR in our architecture studies has bridged the gap between theory and practice. It not only enhances our creativity but also allows for greater interaction with our designs, giving us a better grasp of scale and proportion."

1. **Enhanced Design Exploration:** VR Technology tools such as CAD software and parametric design applications have revolutionized the design process. Students can quickly generate and analyze multiple design iterations, leading to a more iterative and creative approach to design.
2. **Enhanced Visualization:** Advanced rendering software and virtual reality (VR) tools have improved visualization capabilities. VR walkthroughs help students experience spaces before construction, fostering better communication between virtual Reality design educators and students.
3. **Enhanced Collaboration:** VR Technology has broken down geographical barriers, enabling seamless collaboration among students and educators. Online collaboration platforms and video conferencing tools facilitate diverse and enriched learning experiences.

Overall, participants praised VR technology for its positive impact on creativity, communication, and global connectivity within architectural education. The findings underscored VR technology's very importance as a powerful tool shaping the future of architectural learning and practice.

Theme 2: Challenges and Obstacles in Incorporating VR Technology in Architectural Education (Design Subject)

The second theme centers on the challenges and obstacles encountered when incorporating VR technology in architectural education (design subject). Participants from different views, including educators and students, shared their perspectives on the difficulties they faced during their VR design class.

1. Limited Access to VR Technology Resources

Participants expressed concerns about limited access to VR technology resources, particularly in some educational institutions. Educators highlighted the need for updated hardware, software, and VR equipment, which may not always be readily available. An educator remarked:

Respondent 5 says:

"Our university budget constraints hinder us from acquiring the latest technology. It becomes challenging to provide hands-on experiences to all students when VR technology is limited. As well as during our design class we could not reach the required sites that we needed to study since not all the remarkable places have VR technology services."

Respondent 6 says:

"While VR technology has great potential in architectural education, the lack of access to adequate equipment and resources is a major hurdle. Many of us struggle with outdated hardware or insufficient VR setups, making it difficult to fully explore and engage with the designs. It's frustrating knowing that the technology exists but isn't available to everyone equally."

2. Resistance to Change:

Some educators reported facing resistance to VR technology integration from their colleagues and traditional teaching methods. The reluctance to embrace new VR technologies, especially among experienced faculty, posed a significant challenge. One educator shared:

Respondent 7 says:

"Many of my colleagues are apprehensive about using VR technology in their teaching. They prefer conventional methods and believe VR technology might diminish the value of hands-on learning."

Respondent 8 says

"Some of my colleagues still rely on traditional teaching methods and are hesitant to adopt VR in the classroom. They feel that introducing new technologies like VR might overshadow the hands-on experiences that have long been a core part of architectural education."

3. Concerns about Losing Hands-on Experiences:

A common concern voiced by students and educators was the fear of losing the hands-on aspects of architectural education due to VR technology integration. Some students were worried that relying heavily on VR technology might reduce their physical interaction with materials and models. A student mentioned:

Respondent 9 says

"I enjoy working with physical models. I worry that too much VR technology might disconnect us from the tactile experience of architecture."

Respondent 10 says

"I really enjoy building physical models, and I'm worried that if we use VR too much, we'll lose that hands-on experience. There's something about actually working with materials that helps me understand the design better, and I'm not sure VR can fully replace that."

4. Technological Infrastructure Challenges:

Technology experts and educators discussed VR technological infrastructure challenges, especially in remote or underdeveloped areas. Limited internet connectivity and inadequate IT support hindered the smooth integration of VR technology in some universities.

Student A stated:

"Our campus faces connectivity issues, which affects online collaboration and access to digital resources. Improving the infrastructure is a priority needed to make all VR technology easier to access."

Student B stated:

"One of the biggest issues we face is the unreliable internet connection on campus. It makes using VR technology for collaboration really difficult, especially during group projects. Without better infrastructure, it's hard to fully take advantage of what VR can offer in our studies."

Despite the perceived benefits, these challenges presented substantial hurdles in the effective integration of VR technology into architectural education (design subject). Participants' concerns about resource constraints, resistance to change, potential loss of hands-

on experiences, and VR technological infrastructure underscored the need for strategic planning and resource allocation to address these obstacles successfully. It became evident that a balanced approach was essential to leverage VR technology's advantages while preserving the core principles of hands-on learning in architecture education.

Theme 3-Strategies for Successful Integration in Architectural Education

The third theme focuses on the strategies and best practices identified by educators and students for effectively integrating VR technology into architectural education in terms of design subject. Participants, including educators and students, shared valuable insights into successful approaches that facilitated seamless VR technology integration.

1. Professional Development for Educators:

According to the transcripts of the interviews involved two educators mentioned the importance of providing professional development opportunities for lecturers to improve their VR technological skills and pedagogical practices. Workshops, training sessions, and online courses were highlighted as effective means to empower educators with the knowledge and confidence to leverage VR technology in their teaching. An educator stated:

Educator A stated:

"Continuous professional development has been instrumental in building our faculty's capacity to integrate VR technology effectively. We learn from experts and share best practices within our faculty community, so we need to have academic training in terms of the usage of VR technology in education."

Educator B stated:

"The training sessions on VR have been a game changer. Once the teachers feel comfortable with the tech, it's so much easier to bring it into the classroom. Keeping up with new developments and learning from each other has really helped us use VR more effectively."

Educator C stated:

"Workshops and hands-on practice have really helped us get the hang of using VR. It's not just about knowing the technology, but figuring out how to make it really work for the students and improve their learning."

2. Redesigning Curricula to Incorporate VR Technology:

Educators reported redesigning curricula to incorporate VR technology as an essential component of the learning experience. By integrating VR technology-related projects and assignments, students were encouraged to use digital tools to solve architectural challenges. A student shared:

Student D stated:

"Our studio projects now involve VR technology-based components. It's not just about hand drawings anymore; we learn to combine digital tools with traditional methods for comprehensive design solutions. This experience made us feel so excited to check and discover especially since this is a new method to learn."

Student E stated:

"In our design courses now, VR is a key part of the projects. We're blending traditional sketches with digital tools, and it's opened up a whole new way of thinking about design. It's exciting to explore something so different and see our ideas come to life in virtual spaces."

Student F stated

"Using VR in our assignments has really changed how we approach projects. We're not just drawing anymore—we're creating in 3D, which helps us understand our designs on a whole new level. It's a fresh and engaging way to learn."

3. Integration of Virtual Reality (VR):

The integration of VR technologies appeared as a successful approach to enhance architectural learning. Students highlighted how VR allowed students to experience designs in immersive virtual environments, enriching their understanding and creativity. A student expressed:

Student G stated

"The use of VR in our design reviews helps us visualize our ideas in real-world contexts. It adds a new dimension to our design discussions and enables us to make informed decisions."

Student H stated

"VR has completely changed the way we experience our designs. Being able to walk through a virtual version of our projects gives us a much clearer idea of how things will look and feel in the real world. It really enhances our design discussions and decision-making process."

These strategies and best practices emphasized the significance of empowering educators, aligning curricula with VR technology integration, creating supportive environments, and harnessing the potential of VR technologies. Students' and educators' positive experiences with this approach indicated that successful VR technology integration in architectural education requires a holistic and thoughtful approach that considers the needs and aspirations of both educators and students.

Discussion

The results of the study paint a comprehensive picture of the multifaceted impact of virtual reality (VR) technology on architectural education, specifically within the design subject. The first theme, centered on the perceived benefits, reveals a resoundingly positive reception among educators and students. The integration of VR tools, such as CAD software and parametric design applications, has revolutionized the design process and propelled a shift towards a more iterative and creative approach. The enhancement of visualization capabilities and the facilitation of collaboration through VR technology break down geographical barriers, fostering enriched learning experiences globally. This theme establishes VR as a transformative force, positively influencing creativity, communication, and connectivity within architectural education (Ibrahim et al., 2021).

However, the second theme uncovers significant challenges and obstacles in incorporating VR technology into architectural education. The participants expressed concerns about the limited access to VR resources, resistance to change among faculty, fears of losing hands-on experiences, and technological infrastructure challenges. These hurdles underscore the need for strategic planning, resource allocation, and a balanced approach that ensures the

effective integration of VR technology while preserving the fundamental principles of hands-on learning in architecture (Crolla et al., 2024).

The third theme, focusing on strategies for successful integration, offers a roadmap for overcoming challenges. Professional development for educators, curriculum redesign, and the integration of VR technologies emerge as crucial approaches. Empowering educators with the necessary skills, aligning curricula with VR integration, and creating supportive environments underscore the significance of a holistic and thoughtful approach. This theme highlights the importance of both educators and students in successfully integrating VR technology, emphasizing the need for continuous learning and adapting to technological advancements (Williams et al.).

The fourth theme delves into the impact of VR technology on learning experiences and design processes in architectural education. Participants recognize the expansion of creative thinking, improved problem-solving approaches, enhanced collaboration, and access to global knowledge. The positive influence of VR on these aspects underscores its potential to shape a new generation of architects equipped with advanced tools and a global perspective.

The final theme offers practical recommendations for improving VR technology integration in architectural education. Investing in technological infrastructure, fostering interdisciplinary collaboration, engaging VR technological experts, promoting faculty-student cooperation, and emphasizing ethical use emerge as critical suggestions. These recommendations, if implemented, can create a conducive environment for effective VR technology integration, addressing the challenges identified in the study (Aydin & Aktaş, 2020).

In conclusion, the identified themes harmonize effectively with the theoretical framework, particularly aligning with the Technology Acceptance Model (TAM). The core focus of TAM on perceived usefulness and ease of use resonates with participants' positive perceptions of the benefits and accessibility of VR technology. Moreover, the theoretical emphasis on collaboration and active learning aligns seamlessly with the themes related to interdisciplinary projects and heightened student engagement. Nevertheless, participants' nuanced perspectives on preserving core principles and the impact of VR technology on creative thinking reveal additional dimensions beyond the confines of the theoretical framework. This nuanced understanding suggests that comprehending the integration of VR technology in architectural education necessitates a holistic consideration of both theoretical perspectives and the distinctive challenges and opportunities articulated by the participants (Yu et al., 2022).

Furthermore, the study enriches the ongoing discourse on the role of technology in shaping the future of architectural learning and practice. By unraveling the potential benefits, challenges, and offering strategic recommendations, it underscores the significance of a collaborative and forward-thinking approach to harness the full potential of VR technology in architectural education. The findings contribute valuable insights that extend beyond theoretical constructs, emphasizing the dynamic interplay between theory and real-world complexities in the realm of architectural education (Guerra-Tamez, 2023).

The thematic analysis revealed several key findings and insights regarding VR technology integration in architectural education:

1. **Perceived Benefits:** Participants recognized VR technology's positive impact on design exploration, visualization, and collaboration in architectural projects.
2. **Challenges and Obstacles:** Limited access to VR technological resources, resistance to change, and concerns about losing hands-on experiences emerged as significant challenges in VR technology integration.
3. **Strategies for Successful Integration:** Participants emphasized the importance of professional development for educators, curricular redesign, supportive learning environments, and the integration of augmented and virtual reality technologies.

4. Impact on Learning and Design Processes: VR Technology was found to enhance creative thinking, problem-solving, collaboration, and access to global architectural knowledge.
5. Recommendations for Improvement: Participants recommended investing in VR technological infrastructure, facilitating interdisciplinary collaboration, engaging VR technology experts, fostering faculty-student collaboration, and emphasizing ethical use of VR technology.

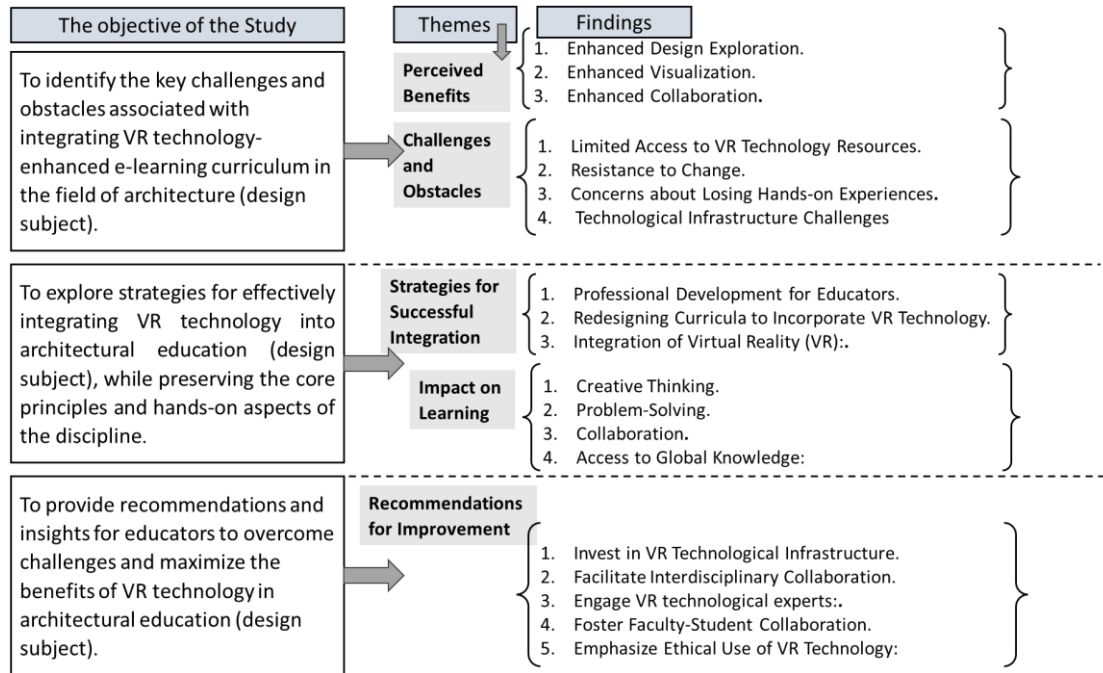


Fig. 5: The Study's Objectives were Achieved by Findings
Source: Authors

The Contribution of TAM to the Results

The Technology Acceptance Model (TAM) significantly contributed to understanding the participants' acceptance of VR technology in architectural education. TAM's core components—perceived usefulness and perceived ease of use—directly aligned with the results, as participants highlighted the accessibility and efficiency of VR tools in improving their design processes and learning experiences. Educators and students found VR technology to be not only a useful addition to their educational toolkit but also easy to integrate into their existing workflows, reinforcing TAM's premise that perceived ease of use drives technology adoption.

Furthermore, TAM's focus on perceived usefulness was evident in how participants appreciated VR's ability to enhance their design exploration, collaboration, and problem-solving skills. The willingness of both students and educators to adopt VR was directly tied to the technology's clear benefits in improving architectural education outcomes, as supported by TAM. The model's theoretical underpinnings helped explain the positive reception of VR technology and its integration into architectural curricula, highlighting the importance of usefulness and usability in shaping attitudes toward new technologies.

Hence, TAM provided a valuable framework for interpreting the study's findings, offering insights into why participants embraced VR technology. By focusing on perceived usefulness and ease of use, TAM illuminated the key factors driving VR adoption in architectural education, helping to clarify the results and support the overall conclusions of the study.

Implications for Architectural Education and Integration of VR Technology

The study's results hold significant implications for architectural education in regard to design subject. Institutions need to address challenges and invest in resources to foster successful VR technology integration. Emphasizing hands-on learning and preserving core principles while embracing innovation is critical. The integration of interdisciplinary collaboration and real-world industry engagement can prepare students for the dynamic architectural landscape.

Conflict of Interest

The authors declare no financial, personal, or professional conflicts of interest that could have influenced the research outcomes. The study was conducted independently and objectively, with no external pressures or influences impacting the design, analysis, or interpretation of the results. All findings and conclusions presented in the article are based solely on the research conducted by the authors. The authors reported no potential conflict of interest.

Conclusion

The study of VR technology integration in architectural education is significant because it has the potential to transform the way architecture is taught and practiced. By incorporating digital tools and VR technologies into the curriculum, students can gain hands-on experience with the latest software and design techniques, and develop the skills needed to be successful in a rapidly changing curriculum. Furthermore, VR technology integration can help bridge the gap between traditional academia and digital academia, ensuring that students are better prepared to meet the demands of the workforce upon graduation (Yu et al., 2022).

In the context of modern education, the study is relevant because it highlights the importance of incorporating VR technology into the curriculum in order to prepare students for the demands of the 21st century. As VR technology continues to advance, it is essential that educators keep pace and provide students with the knowledge and skills they need to succeed in their future careers (Williams et al., 2020).

In terms of architectural practice, the study is relevant because it addresses the need for architects to have a strong understanding of digital tools and VR technologies in order to remain competitive in the current method of learning. As architecture becomes increasingly reliant on VR technology, it is essential that architects have a strong foundation in digital tools and techniques in order to create innovative and sustainable designs.

Future Research and Development

Future research should explore the long-term impact of VR technology integration on architectural practice and the evolving roles of architects. Comparative studies can assess the effectiveness of different VR technology integration strategies. Additionally, investigating the ethical implications of VR technology use and the role of AI and automation in architectural education is essential for preparing students for the future. Continued research and development will enable the ongoing enhancement of VR technology integration in architectural education.

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