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Architectural Education Using Virtual Reality: A Case Study in Department of Architecture, University of Jos, Nigeria

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Abstract: ***In 2020, the world faced the unprecedented challenge of the COVID-19 pandemic, resulting in widespread lockdowns. This situation necessitated a rapid shift towards virtual communication, forcing society to adapt to this new reality. Consequently, there arose a compelling need to explore technological innovations for enhancing architectural education. This research was dedicated to examining the perspectives of lecturers in the University of Jos's Department of Architecture regarding the use of virtual reality as an educational tool. Employing a qualitative approach, the study delved into their beliefs, attitudes, and opinions regarding virtual reality. From a pool of 33 potential participants, seven lecturers were purposefully selected based on specific criteria such as qualifications and experience, and they were subsequently interviewed. The findings conveyed that lecturers generally view virtual reality as a promising teaching aid. However, they also highlighted obstacles, including the cost of VR equipment and the need for more extensive training among lecturers. To overcome these challenges, the study recommends a gradual integration of virtual reality courses into the curriculum, along with comprehensive training for both lecturers and students.***
Keywords: Virtual Reality, Headset, Communication, Education

1.0 Introduction

1.1 Background of The Study

The world is rapidly changing, prompting architects and architectural educators to adapt. In 2020, the COVID-19 pandemic forced a shift to virtual communication for many, emphasizing the need to integrate technology into architectural education. Virtual Reality (VR) technology, known for its effectiveness in enhancing architectural programs (Wang, 2018), emerged as a valuable tool.

VR offers immersive visual experiences, allowing users to explore virtual spaces, grasping size, orientation, and proportion firsthand. This technology enhances comprehension and visualization (Virtual Reality Society, 2016). VR creates an almost-real digital environment, blending "virtual" and "reality," making it appear genuine (Virtual Reality Society, 2016).

In the field of healthcare, VR shows potential for diagnosing various medical conditions, from social anxiety to chronic pain, although it's still in its early stages (Mandal, 2013).

Two key elements of VR are immersion and interaction. VR systems fall into three categories based on immersion levels: immersive, semi-immersive, and non-immersive. Immersive VR provides the deepest experience, closely simulating a virtual world but is complex and costly. Semi-immersive systems offer a high level of immersion with more familiar tools and gadgets, while non-immersive VR is the least immersive and budget-friendly, often utilizing glasses and display screens (Fuchs, 2011). These advancements in VR technology offer exciting possibilities for architectural education and beyond.

1.2 Statement of the Problem

Contemporary architectural presentations typically use 2D formats, occasionally incorporating 3D elements like photos, computer renders, and videos. However, this limits the understanding of designs as they remain on a 2D plane. Virtual reality allows users to fully experience and understand designs in 3D. This study aims to assess lecturers' perceptions of using virtual reality in architectural design projects and its potential for enhancing architectural education by bridging the gap between theory and practice.

1.3 Research Questions

1. How can Virtual reality be used as a tool for effective learning in architectural education?
2. How do the educators of architecture perceive the use of virtual reality?

3. How can virtual reality be integrated into architecture education?
4. How can virtual reality assist in field trips and case studies?

1.4 Aim and Objectives

This study seeks to examine how experienced architecture educators in higher institutions perceive virtual reality and explore its potential as a valuable learning tool. To accomplish this, the study will pursue the following objectives:

1. to highlight the different applications of VR in architectural education
2. to investigate how lecturers, perceive virtual reality in the Department of Architecture
3. to explore how Virtual Reality can bridge the gap being theoretical and practical teaching approaches.
4. to evaluate how VR can be used in facilitating case studies and departmental field trips

2.0 Literature Review

2.1 Virtual Reality

Virtual Reality (VR) technology, introduced in the 1980s with systems like Head head-mounted displays (HMDs) and data suits connected to computers, created three-dimensional simulated environments (Philip Brey, 2014). Although the term "VR" emerged in the 1980s, its development dates back further. Key milestones include Edward Link's flight simulator in 1929, Morton Heilig's Sensorama in 1956, and the first interactive architectural virtual walkthrough system at UNC between 1970 and 1985. Scott Fisher established the NASA VIEW lab in 1984, with the first BOOM head-based display in 1987. Howard Rheingold's 1991 definition characterizes VR as a 3D computer-generated environment where users can move and interact from various angles.

2.2 Virtual Reality in Architectural Design Education and Communication

VR enhances communication for architects, contractors, and investors, allowing them to showcase projects before completion. Clients can actively engage in the design process, improving prototyping. Around 43% of architectural studios and 22% of design firms use VR for client interaction (CGArchitect research). VR is a valuable tool for perceiving architectural designs (Chan, 1997).

(1) In education, VR helps students and lecturers understand spatial qualities, proportions, and materials. Pre-construction walkthroughs enable last-minute design adjustments and error corrections (Neil, 1996). VR offers advantages like enhanced understanding of structures, streamlined collaboration, increased productivity, and cost reduction (Mobach, 2008). It also supports decision-making, design analysis, and problem-solving, akin to physical mock-ups.

The University of Strathclyde was the first to incorporate a virtual environment lab into its architecture program in order to improve the structure and pace with which students are educated. Also, the University of Bialystok in Poland has created virtual cities and autonomous buildings for students to tour in order to better comprehend city planning and architectural integrity. Additionally, the University of Cincinnati has integrated a variety of architectural components in the virtual format for students to explore and learn in greater depth.

Integrating Virtual Reality (VR) into construction design enhances the students' understanding of assembly and structural properties (Abdelhameed, 2013). M.E. Haque's 2006 application uses 3D visualizations and VR to demonstrate construction processes, aiding self-learning for students.

Traditional teaching in building construction courses lacks engagement. Leveraging information technology and VR can transform building construction education, making it more effective and engaging, improving student comprehension of construction and structural concepts.

2.3 Perception of Virtual Reality by Lecturers

This research reviews past studies concerning the perception of virtual reality (VR) among higher education lecturers and teachers. VR in education is seen as a tool that can engage students, introduce them to new insights, and motivate them. Traditional teaching methods have been teacher-centered, with students relying on provided materials, which can be unengaging, particularly for those uninterested in the subject.

The Diffusion of Innovations theory emphasizes the significance of people's attitudes toward technology adoption. Factors influencing technology integration include student and teacher perceptions, institutional support, integration barriers, rationale, and prior experience.

While some research supports the benefits of VR for learning, others have found negative effects, especially in STEM, history, and language learning. It's challenging to establish a clear consensus on the effectiveness of VR in education due to its relatively new and limited adoption.

A case study by Alfalah (2018) focused on teachers' attitudes toward using VR for information technology instruction at a Middle Eastern university. The sample, information technology instructors, generally had a positive attitude toward VR, but this group is naturally more tech-savvy.

Hussein and Nätterdal (2015) emphasized VR's potential to enhance architectural education, offering hands-on learning and interactive experiences. Mantovani (2001) noted VR's application in various fields, including military training, law enforcement, and research institutes.

In medical education, VR allows students to learn through trial and error in a safe environment. Anatomical VR systems, like Anatomic VisualizeR and 3D Human Atlas, offer students interactive experiences and standardized training. However, VR's full integration faces challenges such as equipment costs, cybersickness, overheating, and the need for teacher training and curriculum modification (Alfalah, 2018).

2.4 Virtual Reality As A Bridge Between Theory And Practice

Higher education's overreliance on second-hand knowledge, detached from firsthand experience, is a common concern (Gillett-Swan, 2017). Students may excel in tests but struggle to apply knowledge practically (Mazur, 2021). Perceived usefulness (PU) and perceived ease-of-use (PEOU) are key factors in technology acceptance (Davis, 1989). Knowledge integration and real-world application enhance learning (Merrill, 2002).

The paper aims to bridge the theory-practice gap in architecture education using VR. Traditional teaching tends to prioritize second-hand knowledge, but practical experience is vital (Lauritsen, 2012). VR can facilitate this shift.

Site-based experiences in teacher education help connect theory and practice (Barksdale-Ladd et al., 1997). Real-world performance is a better indicator of learning than factual knowledge (Makranksy, 2019).

Various learning techniques can be employed in higher education, including individual learning, group presentations, and interactions (Valzolgher, 2020). Multimedia computers and VR, particularly Desktop Virtual Reality (DVR), have been explored as effective learning media (Scavarelli, 2021).

Despite the potential of VR in improving learning outcomes, questions remain about its effectiveness (Huang, 2020).

Combining various technologies, such as virtual field trips (VFTs), offers a means to engage students in the 21st century. VFTs provide advantages like inclusivity, skill development, and enhanced engagement (Cliffe, 2017). While traditional field trips have traditionally been associated with high-quality learning (Falk, 1997), they can be burdened by costs and safety concerns (Herrick, 2010).

Virtual field trips (VFTs) represent a technology-driven alternative. They deliver a quality learning experience, mitigating some of the limitations of physical field trips (Turney, 2009). The integration of 360-degree technology further enriches the VFT experience.

Among the array of educational technologies, virtual reality stands out due to its interactive multimedia capabilities (Semple, 2000). VFTs prove invaluable in achieving specific learning objectives, especially when real-world environments are inaccessible (Harrington, 2011).

3.0 Research Methodology

3.1 Methodology

This study utilized an exploratory approach with a pre-test/post-test survey design. This design involved conducting a survey before participants experienced virtual reality (VR) technology to gauge their expectations, views, and attitudes. After the VR experience, the same participants completed the survey again to assess any changes in their perspectives.

Additionally, the study employed other data collection methods, including field studies and case studies, for a comprehensive understanding of participants' VR experiences. This design facilitated efficient data collection across a broad area and provided insights into the entire population based on a sample (Kothari, 2003).

RESEARCH DESIGN

This study utilized qualitative research with a PRE-TEST/POST-TEST Design. Qualitative research was chosen to explore the subject, gather participant experiences, and develop theories. The design involved conducting a survey before participants used virtual reality technology to assess their initial beliefs and expectations. After the VR experience, the same participants completed the survey again to evaluate changes in their attitudes and opinions regarding VR (Mugenda, 2003; Creswell, 2012).

AREA OF STUDY

The area being studied for the purpose of this research is the Department of architecture which is located in the University of Jos Permanent Site at Jos North Local Government area of Plateau State, Nigeria. This area is occupied by Nigerians from various tribes. It is characterized by educational buildings and recreational buildings as well.

TARGET POPULATION

The design allowed the researcher to efficiently gather data from a broad geographical area and gain insights into the entire population through a representative sample (Kothari, 2003). The study focuses on a target population comprising 33 lecturers who are registered architects and hold teaching positions at the Department of Architecture, University of Jos, Nigeria.

SAMPLE AND SAMPLING TECHNIQUE

According to Kothari a sampling technique is the procedure a researcher will adopt/use in selecting some sampling units from which inferences about the population can be drawn. The total population of lecturers in the Department of Architecture is thirty-three (33) there are 4 professors and 9 lecturers with a doctorate degree. The purposive sampling technique Also known as subjective sampling is a non-probability technique where the researcher relies on their discretion to choose variables for the sample population. Here, the entire sampling process depends on the researcher's judgment and knowledge of the context. this was used to obtain a sample size of 7 participants who are registered architects and fully employed lecturers.

Table 1: Demographics of the respondents

Participants	1	2	3	4	5	6	7
Sex	Male	Male	Male	Male	Male	Male	Female
Profession	Architect and lecturer	Architect and lecturer	Architect and lecturer	Architect and lecturer	Architect and lecturer	Architect and lecturer	Architect and lecturer
Years of experience	1-5 years	1-5 years	6-10 years	10-15 years	15-20 years	15-20 years	10-15 years

INSTRUMENT FOR DATA COLLECTION

Semi-structured interviews were employed to gather information from the participants. Interviews represent a widely utilized qualitative research technique and are particularly valuable for obtaining insights in case studies due to their flexibility (Yin, 2014). Through interviews, the researcher delved deeper into the subject matter, gaining fresh perspectives from the respondents. Recognizing the potential for biases to affect data quality, the researcher took great care to pose impartial questions.

The interview process consisted of two stages: one conducted prior to the participants' exposure to virtual reality and another conducted after they had experienced virtual reality.

METHOD OF DATA ANALYSIS

In this research, interviews were conducted with lecturers, who play a crucial role in educating future architects. These interviews were held in various locations such as offices, classrooms, and seminar rooms, and were recorded with the participants' consent. The recorded audio was transcribed into text using Microsoft Word software. The analysis process involved categorizing each participant's responses into three super themes: perceived usefulness of virtual reality (VR) in learning, perceived ease of use, and perceived challenges to the adoption of VR for teaching and learning. Each response was then coded to the corresponding super theme. This coding process helped organize and link the data for analysis, as illustrated in the figure included in the research.

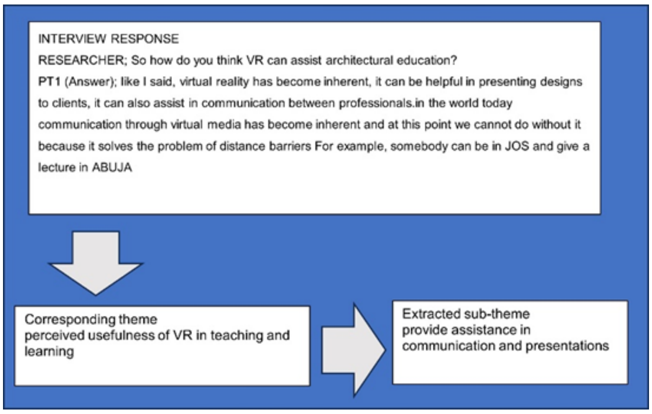

Figure 1: shows the process of data analysis

4.0 Findings and Discussion

4.1 Procedure of Data Collection

This part of the paper lays emphasis on the procedure the researcher used in collecting data and also the equipment used for data collection. It is divided into two stages; the pre-demonstration stage, and the post-demonstration stage.

The pre-demonstration section outlines the setup of VR equipment and the steps in creating the VR application.

Steps in VR Application Development:

1. Select a 2D building case study.
2. Create a 3D model using AutoCAD.
3. Import materials (e.g., stone, iron, concrete) into the 3D model using 3Ds Max.
4. Transfer models from 3Ds Max to game engine software for VR development.
5. Utilize a Samsung Gear VR headset.
6. Create or log into an Oculus account for Gear VR functionality.
7. Adjust focus using the device's dial.
8. Navigate the VR interface.
9. Invite participants to the research study.
10. Obtain participant consent for data confidentiality.
11. Conduct pre-VR experience interviews to assess opinions and beliefs.

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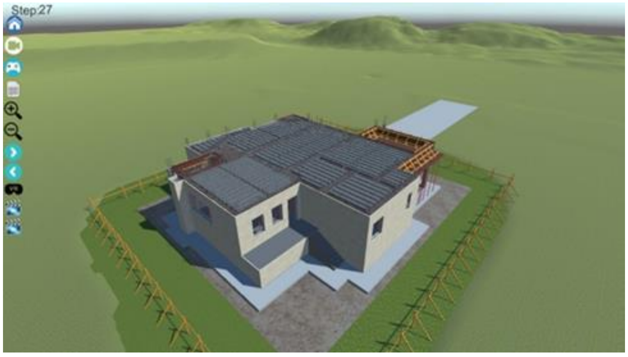

Figure 2: An immersive virtual environment scene (Bird View camera)

Post-demonstration stage of the paper lays emphasis on the events that took place after the participants had the virtual experience. At this stage, the respondents made sure of the Gear VR headgear to navigate the designed structure. After the VR navigation experiences, the participants were interviewed.

4.2 Research Findings

Demographics of the 7 respondents included 1 female and 6 males aged between 17 and 55. Prior to the demonstration, respondents were queried about their prior experience with virtual reality (VR). The table below presents the results of their VR usage and experience, evaluated on a 5-point Likert scale ranging from novice, beginner, regular, professional and master. This assessment aimed to gauge their perspectives and insights regarding virtual reality based on their familiarity with the technology.

4.3 Research Questions

RESEARCH QUESTION ONE; HOW CAN VIRTUAL REALITY BE USED AS A TOOL FOR EFFECTIVE LEARNING IN ARCHITECTURAL EDUCATION?

The findings suggest that virtual reality (VR) has potential applications in specific architecture courses, with the design studio being highlighted as a primary candidate. Most participants agreed that VR could be utilized to emphasize aspects like anthropometrics and scale in design. However, there were concerns about the technical knowledge of lecturers, with one participant expressing doubt about its effective use due to the need for adaptation to new technology. Nevertheless, many participants welcomed the idea, recognizing VR's value in overcoming distance barriers. Additionally, participants identified various areas where VR could be applied, including field trips, case studies, presentations, collaborative communication, and concept formation. Notably, one participant highlighted the cost-saving potential of VR for field trips and its potential to spark students' passion for architecture, aligning with previous research findings.

RESEARCH QUESTION THREE; HOW CAN VIRTUAL REALITY BE INTEGRATED INTO ARCHITECTURE EDUCATION?

The study employed a pretest and post-test approach to gauge lecturers' perceptions of virtual reality (VR) in education. Participants were surveyed before and after a VR demonstration. One participant (pt5) initially expressed reservations, viewing VR as a new and unfamiliar realm that would require re-education to be effectively used for educational purposes. However, after experiencing VR, this same participant recognized its untapped potential and envisioned it as a valuable tool for design and communication, aligning with Mantovani's perspective on VR's role in enhancing the learning experience.

Conversely, two participants (pt2, pt4) held concerns about the cost associated with VR equipment and training, suggesting potential barriers to its widespread integration. PT2 welcomed the idea but acknowledged its expense and limited awareness. PT4 highlighted economic factors, citing the availability and affordability of existing computer-aided design (CAD) software as an alternative to VR.

RESEARCH QUESTION THREE; HOW CAN VIRTUAL REALITY BE INTEGRATED INTO ARCHITECTURE EDUCATION?

Regarding the role of VR in bridging theoretical and practical teaching methods, the majority of participants expressed optimism about its potential to significantly enhance the learning process. For instance, PT1 highlighted that VR in the classroom could create an environment that fosters creativity without constraints. This aligns with Pantelidis (2010), who emphasized VR's capacity for promoting active learning and providing an engaging educational setting.

Additionally, PT5 pointed out that VR can address language barriers, a sentiment supported by Pantelidis (2010), who emphasized VR's ability to overcome language differences through features like chat rooms, games rooms, and forums, facilitating communication among individuals from diverse cultural backgrounds.

Moreover, PT6 envisioned VR's utility in teaching architectural history by enabling students to virtually explore global and local destinations. This approach allows students to grasp concepts related to various architectural styles and materials, going beyond theoretical explanations.

RESEARCH QUESTION FOUR; HOW CAN VIRTUAL REALITY ASSIST IN FIELD TRIPS AND CASE STUDIES?

Regarding field trips, case studies, and historical exploration, the majority of participants (specifically, participants 1, 3, 4, and 6) concurred on the potential value of virtual reality due to its cost-saving benefits. PT1 emphasized that the department had not organized field trips recently, not by choice but due to the financial demands associated with transportation and accommodations. Virtual reality was seen as a solution to this issue. PT3 supported this notion, suggesting that funds allocated for trips could be redirected to virtual reality usage.
PT4 expressed concerns about the security situation in the country, citing recent incidents of kidnappings and robberies. Virtual reality was perceived as a safer alternative, reducing travel-related risks for students.

Furthermore, PT6 echoed the sentiment expressed by Hunter (2004) regarding students' practical exposure in a simulated environment. PT6 highlighted that modern students often struggle with prolonged attention spans, making virtual environments an engaging and memorable learning tool.

5.0 Conclusion and Recommendations

5.1 Conclusion

This study addresses the limited literature on the adoption of VR in Nigeria by examining how lecturers at the University of Jos perceive the ease of using VR, its utility in education, and the challenges associated with its implementation. Unlike previous research, which primarily focused on lecturers' perspectives, this study emphasizes the viewpoint of students regarding the potential applications of VR. It underscores the significance of virtual reality (VR) as a valuable tool, offering a secure learning environment for practicing intricate procedures through realistic simulations.

5.2 Recommendations

This research suggests a need for a more comprehensive investigation into the factors influencing VR adoption in Nigeria. Such a study should employ a robust theoretical and methodological framework and should encompass the perspectives of both students and lecturers from multiple institutions. It would be particularly intriguing to explore variations in opinions regarding VR adoption among different types of students and lecturers in higher education institutions, including conventional, research-focused, and teaching-oriented ones.

- Additionally, further research should assess the practicality of introducing VR into architectural education, considering the existing infrastructure, financial implications for Nigerian educational institutions, and relevant educational policies."

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