Enhancing Building Technology Education through the Integration of Virtual Reality

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Abstract: *This study investigated the role of Virtual Reality (VR) in enhancing building technology education across Nigerian tertiary institutions. Data were gathered from 162 respondents, including Educators and Students, via a survey. Descriptive and inferential statistics revealed moderate familiarity and limited institutional adoption of VR (mean = 2.29). However, the respondents demonstrated a strong awareness of its potential benefits (mean = 3.64) and relevance in bridging practical skill gaps (mean = 4.46). Notable challenges of utilizing VR included inadequate infrastructure, financial constraints, and limited training opportunities, corroborating global and local findings. Despite these barriers, VR was perceived as highly effective in improving student engagement (mean = 4.67) and practical skill development (mean = 4.72). Statistical analyses confirmed significant differences in perceptions between educators and students regarding familiarity and challenges ($p < 0.05$). The study emphasizes the need for strategic investments and curriculum restructuring to harness VR's potential in addressing skill gaps in Nigeria's building technology education, while proposing an implementation strategy for integrating VR into curricula, which includes developing VR modules that align with educational objectives, investing in necessary technology and infrastructure, and providing comprehensive training for educators. This research furnishes valuable perspectives on leveraging VR to enhance building technology education, with the ultimate objective of enhancing educational accomplishments and better equipping students for careers in the field.*

Keywords: virtual reality, building technology education, curriculum development, student engagement, Nigerian tertiary education

INTRODUCTION

The emergence of technology has brought about a significant transformation in various sectors on a global scale, most notably in the field of education. Virtual Reality (VR) stands out as a prime example of technological progress that has garnered attention for its potential to enrich educational experiences. VR presents users with immersive, interactive settings that have the capacity to enhance learning outcomes substantially by offering hands-on experiences that are practical and realistic, free from the limitations of physical reality (Radianti et al., 2020; Freina & Ott, 2015; Huang et al., 2013). Within the realm of building technology education, VR has the ability to replicate real-world scenarios, enabling students to interact with intricate concepts and procedures within a safe and controlled setting (Sampaio et al., 2010; Wang & Dunston, 2007).

Historically, Nigerian higher education institutions have encountered several challenges in delivering effective building technology education. These obstacles encompass insufficient infrastructure, restricted access to modern learning resources, and a disparity between theoretical knowledge and its practical application (Umar et al, 2023; Opoola, 2020; Obadoyin, 2018). The conventional lecture-based teaching method often falls short in adequately equipping students for the practical requirements of the construction sector, resulting in a workforce that lacks crucial hands-on experience. The integration of VR into the building technology curriculum could potentially tackle these challenges by offering students realistic and interactive learning experiences that bridge the gap between theory and practice (Soliman et al., 2021).

The effectiveness of VR technology has already been evident in various educational domains, such as medicine, engineering, and the arts (Jensen & Konradsen, 2018; Pantelidis, 2010). Its utilization in building technology education can deliver immersive simulations of construction sites, structural design projects, and maintenance procedures, thus enhancing students' comprehension and retention of intricate concepts (Abulrub et al., 2011; Whyte et al., 2000). For example, students can visually explore and engage with 3D building models, perform virtual site inspections, and experiment with diverse construction methods in a secure environment (Bouras et al., 2008).

Despite the potential advantages, the implementation of VR in Nigerian tertiary institutions remains constrained. Challenges such as high implementation costs, a lack of technical expertise and resistance to change present significant obstacles (Ugwuanyi et al., 2022; Okolie et al., 2019). Furthermore, there is a necessity for revising the curriculum to effectively integrate VR into existing educational frameworks (Merchant et al., 2014). Nevertheless, given the increasing affordability of VR technology and the growing acknowledgment of its educational benefits, there is an urgent need to explore its integration into building technology education in Nigeria (Onele, 2020).

The integration of Virtual Reality (VR) into building technology education stands as a prospective remedy through the provision of immersive, practical learning experiences that correspond with current industry standards. VR technology has the capacity to simulate diverse construction scenarios, ranging from initial planning and design to execution and maintenance, enabling students to hone their skills within a secure and supervised environment (Fowler, 2015). However, the advancement of building technology education within Nigerian tertiary institutions faces several challenges, such as outdated teaching methods, insufficient practical training, and a lack of modern facilities. These challenges result in a gap between academic instruction and industry requirements, leading to graduates who lack readiness for the workforce. Conventional educational methods often prioritize theoretical comprehension over practical proficiencies, which proves inadequate for a discipline necessitating practical experience and problem-solving skills in real-world contexts.

This research endeavor is focused on exploring the viability of VR in enhancing building technology education across Nigerian tertiary institutions, while identifying the barriers and facilitators influencing its effective integration. Two Hypotheses were explored in this study; (1) There is a significant difference between the responses of Educators and Students on their perceptions and experiences with VR in building technology education (2) There is a significant difference between the responses of educators and students on the challenges affecting the effective integration of Virtual Reality in Building technology education.

LITERATURE REVIEW

Overview of Building Technology Education

Building technology education is of paramount importance in the acquisition of the necessary skills and knowledge essential for the construction and architectural sectors. This field encompasses a diverse array of subjects, including architectural design, construction techniques, materials science, and structural engineering (Emmitt & Gorse, 2013). Its principal objective is to equip students with the competence to meet both the practical and theoretical demands of the building industry. The integration of contemporary construction technologies into the curriculum has progressively gained significance to ensure the readiness of graduates to confront modern challenges in the field (Becerik-Gerber et al., 2011).

In Nigeria, the focus of building technology education has traditionally leaned towards theoretical aspects, with practical application being somewhat limited (Aina et al., 2019). This approach frequently results in graduates being under-prepared for the realities of the construction sector, where hands-on experience and practical skills are essential (Okolie et al., 2019). The existing disparity between academic instruction and industry requirements underscores the necessity for an enhanced curriculum incorporating increased practical exposure and the integration of contemporary technologies (Alagbe et al., 2020).

Educators and industry experts widely concur on the critical nature of advancing building technology education to elevate the quality of construction projects and bridge the industry's skills gap (Ogunyemi, 2014). The adoption of innovative teaching methods and technologies, such as virtual reality (VR) and augmented reality (AR), can furnish students with immersive learning encounters that effectively bridge the chasm between theory and application (Freina & Ott, 2015).

Challenges in Building Technology Education in Nigeria

Building technology education encounters several significant challenges in Nigeria. A fundamental challenge is the insufficiency of adequate infrastructure and resources crucial for effective teaching and learning (Aina et al., 2019). Outdated equipment and inadequate facilities in many institutions impede the provision of hands-on training, consequently affecting educational quality and graduates' readiness for the industry (Alagbe et al., 2020).

The lack of alignment between the curriculum in Nigerian institutions and the evolving requirements of the construction sector poses a significant issue (Ugwu et al., 2020). A disparity exists between classroom teachings and practical field skills, resulting in graduates who are not fully equipped to meet industry demands. Continuous review and updating of the curriculum are imperative to ensure its alignment with current industry standards and practices (Okolie et al., 2019).

Furthermore, a notable challenge is the scarcity of qualified educators possessing both academic knowledge and industry expertise. Many instructors have strong theoretical foundations but lack essential practical industry experience, vital for teaching applied skills (Eze & Chinedu-Eze, 2020). This knowledge gap impacts educational quality and the effectiveness of student preparation for the professional realm.

Financial constraints also significantly impede the quality of building technology education. Several institutions lack the required funding for modern equipment, training programs and faculty development (Ayo-Vaughan et al., 2020). This financial inadequacy limits institutions' capacity to integrate innovative technologies and methodologies that could enhance learning outcomes.

The Role of Technology in Modernizing Education

The integration of technology in the field of education holds the potential to transform the learning process significantly through increased engagement, interactive learning experiences, and enhanced educational outcomes. Within the realm of technology-enhanced education, tools like Virtual Reality (VR), Augmented Reality (AR), and Building Information Modeling (BIM) have the capacity to establish immersive and interactive learning environments (Sacks et al., 2013). These technological advancements enable students to visualize complex structures, engage in virtual site visits, and collaborate on design projects in real-time, thereby offering a more experiential learning approach (Abulrub et al., 2011).

Virtual Reality (VR) and Augmented Reality (AR) play a pivotal role in enriching the learning journey by granting students the opportunity to engage with 3D models, simulate construction procedures, and explore virtual settings (Freina & Ott, 2015). These technologies render abstract concepts more tangible and comprehensible, ultimately enhancing understanding and memory retention (Pantelidis, 2010).

Building Information Modeling (BIM) stands out as another indispensable technological tool that can revolutionize the realm of building technology education. BIM revolves around generating and overseeing digital representations of both the physical and functional attributes of spaces. It empowers students to work with detailed and comprehensive digital models of construction ventures, thereby fostering improved comprehension and collaboration (Sacks et al., 2013). Moreover, BIM aids in developing students' skills in project management, design and construction, all of which are essential in today's construction industry (Whyte et al., 2000).

The integration of these advanced technologies in educational settings promotes personalized learning, allowing students to progress at their own pace and cater to their unique educational requirements (Dede, 2009). Furthermore, it facilitates the utilization of simulations and virtual laboratories, which can replicate real-world scenarios and offer practical experience devoid of physical constraints (Jensen & Konradsen, 2018).

Benefits of Integrating Virtual Reality in Education

Virtual Reality (VR) presents a wide range of advantages for educational purposes, particularly in disciplines that necessitate hands-on and practical learning experiences. VR has the capability to establish immersive learning environments that engage students and enhance their understanding of complex concepts (Radianti et al., 2020). By utilizing VR simulations, students can hone their skills and implement their knowledge within a safe, secure and controlled environment, which proves to be notably advantageous in the realm of construction and architectural education (Pantelidis, 2010).

Within the realm of building technology education, VR has the capacity to replicate construction sites, architectural designs and structural engineering projects, providing students with a practical experience that is often absent in conventional educational environments (Sampaio et al., 2010). These simulations empower students to navigate and interact with virtual environments, carry out virtual site inspections and experiment with various construction techniques (Bouras et al., 2005).

Moreover, VR fosters collaborative learning by enabling students to work together on virtual projects, exchange ideas, and obtain prompt feedback from instructors and peers (Whyte et al., 2000). This collaborative method enhances learning outcomes and prepares students for collaborative work and effective communication, which are crucial skills within the construction sector (Freina & Ott, 2015).

Additionally, VR serves to bridge the gap between theoretical knowledge and its practical implementation. By affording students, the opportunity to visualize and engage with 3D models, VR aids in their comprehension of spatial relationships and structural intricacies in building projects (Huang et al., 2019). This experiential learning strategy bolsters retention, understanding, and the capability to employ knowledge in real-world situations (Merchant et al., 2014).

Challenges in Integrating Virtual Reality in Nigerian Tertiary Institutions

Despite the potential benefits of Virtual Reality (VR) in the field of education, the integration of this technology in tertiary institutions in Nigeria is confronted by several notable challenges.

1. One of the main hurdles pertains to the considerable expenses associated with acquiring VR equipment and the necessary infrastructure (Okolie et al., 2019). Many institutions grapple with limited financial resources, making it difficult to cover the initial costs essential for implementing VR technology (Eze & Chinedu-Eze, 2020). These financial constraints impede the widespread adoption of VR within educational settings.

2. Another obstacle lies in the insufficient technical expertise required for the implementation and maintenance of VR systems. Effective utilization of VR technology requires specialized training for both educators and IT personnel, a proficiency that is lacking in numerous Nigerian institutions (Ugwuanyi et al., 2021). This dearth of technical expertise compromises the capacity to embed VR into the academic curriculum effectively, thus underutilizing its potential in enhancing the educational experience.

3. Furthermore, there exists a resistance to change among faculty members and administrators, who may exhibit reluctance in embracing novel technologies and deviating from conventional teaching methodologies (Ayo-Vaughan et al., 2020). Overcoming this resistance necessitates demonstrating the value and efficacy of VR in enhancing educational outcomes, alongside offering assistance and training to educators for adapting to new instructional tools and approaches.

4. The integration of VR into the academic curriculum also demands meticulous planning and restructuring of the syllabus to ensure that VR activities align with the intended learning objectives and outcomes (Merchant et al., 2014). This procedure can be laborious and demanding in terms of resources, further complicating the incorporation of VR into educational practices (Huang et al., 2019).

RESEARCH METHODOLOGY

Population and Sample

The target population for this study includes Educators and students across different levels of study from selected Nigerian tertiary institutions offering building technology programs. The sample size was determined using Taro Yamane formula for sample size determination and purposive sampling method was employed. The computed sample size is 175. Purposively, the sample was distributed 30% (50) to Educators and 70% (125) to students (Etikan et al., 2016).

Data Collection Methods

Data collection involved both primary and secondary sources to ensure a robust analysis.

Primary Data

Primary data was collected through survey method. A structured questionnaire was distributed to students and educators, to gather quantitative data on their perceptions and experiences with VR in building technology education and gain deeper insights into the challenges and benefits of integrating VR into the curriculum. The questionnaire was distributed both online and in-person.

The response was 27.4% (48) return rate for Educators and 65.1% (114) return rate for students, which gives a total of 92.5% (162) return rate.

Secondary Data

Secondary data was sourced from academic journals, institutional reports, and industry publications to provide a contextual background and support the primary data findings.

Data Analysis Methods

Quantitative data from surveys were analyzed using statistical software (SPSS version 26) to perform descriptive and inferential statistical analyses. Descriptive statistics (mean and standard deviation) provided a summary of the data. Inferential statistics (Independent samples t-tests and Pearson chi-square tests) were used to test hypotheses and identify significant differences in responses between groups (IBM Corp., 2019).

Descriptive Analysis of Educators and Students Perceptions and Experiences with Virtual Reality in Building Technology Education

Item statement	Extremely familiar 5	Very familiar 4	Moderately familiar 3	Slightly familiar 2	Not at all familiar 1	Mean	Standard Deviation
How familiar are you with the concept of Virtual Reality (VR)?	0 0%	73 45.1%	27 16.7%	45 27.8%	17 10.5%	2.96	1.07

Table 1: familiarity with the concept of virtual reality.

Item statement	Extensive Experience 4	Moderate Experience 3	Limited Experience 2	No Experience 1	Mean	Standard Deviation
Have you had any prior experience using Virtual Reality in an educational context?	0 0%	81 50%	54 33%	27 17%	2.33	0.74

Table 2: Prior experience using virtual reality in an educational context.

Item statement	Extremely Aware	Very Aware	Moderately Aware	Slightly Aware	Not Aware at all	Mean	Standard Deviation
To what extent are you aware of the potential benefits of integrating Virtual Reality in Building Technology education?	29 18%	72 44%	44 27%	8 5%	9 6%	3.64	1.01

Table 3: Awareness of the potential benefits of integrating Virtual Reality in Building Technology education.

Item statement	Extremely Relevant	Very Relevant	Moderately Relevant	Not Relevant at all	Mean	Standard Deviation
How do you perceive the Relevance of Virtual Reality in addressing practical skills gaps in Building technology?	84 51.9%	69 42.6%	9 5.6%	0 0%	4.46	0.60

Table 4: Perception of the relevance of Virtual Reality in addressing practical skills gaps in Building technology.

Item statement	Used Extensively	Used Moderately	Used in a few instances	Not Used at all	Mean	Standard Deviation
To what extent is Virtual Reality Used in Your Institution?	0 0%	65 40%	79 49%	18 11%	2.29	0.65

Table 5: Extent to which Virtual Reality is used in their institution.

Item statement	Extremely effective	Very effective	Moderately effective	Slightly effective	Not effective at all	Mean	Standard Deviation
How effective do you believe Virtual Reality is in enhancing student engagement in Building Technology education?	109 67%	53 33%	0 0%	0 0%	0 0%	4.67	0.47

Table 6: perception on the effectiveness of Virtual Reality in enhancing student engagement in Building Technology education.

Item statement	Transformational impact	Significant impact	Moderate impact	Limited impact	No impact	Mean	Standard Deviation
In your opinion, what impact does Virtual Reality have on students' practical skills development?	126 77.8%	27 16.7%	9 5.6%	0 0%	0 0%	4.72	0.56

Table 7: Impact of virtual reality on students' practical skills development

Item statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Standard Deviation
Overall, VR technology is a valuable tool for enhancing building technology education	144 89%	18 11%	0 0%	0 0%	0 0%	4.89	0.32
Increased support from stakeholders (e.g., government, industry partners) would facilitate better integration of VR in our institution	136 84%	26 16%	0 0%	0 0%	0 0%	4.83	0.37

Table 8: Virtual Reality as a valuable tool for enhancing building technology education and increased support from stakeholders as a facilitator of VR integration.

Crosstabulation

Challenges to Effective VR integration		Role		Total
		Educator	Student	
Lack of infrastructure	Count	42	76	118
	% within Q1	87.5%	66.7%	
Financial constraints	Count	42	76	118
	% within Q1	87.5%	66.7%	
Limited training opportunities	Count	42	112	154
	% within Q1	87.5%	98.2%	
Resistance from educators	Count	40	65	105
	% within Q1	83.3%	57.0%	
	Count	48	114	162

Table 9. Cross-tabulation of responses on the challenges to effective VR integration

Interpretation

The crosstabulation data highlights key challenges faced by both educators and students in integrating Virtual Reality (VR) into Building Technology education. A majority of educators (87.5%) and students (66.7%) view lack of infrastructure as a major barrier, and a similar proportion find financial constraints to be a significant limitation. Additionally, limited training opportunities stand out as a critical issue, with almost all students (98.2%) and most educators (87.5%) indicating a need for better training access. Resistance from educators is another noted challenge, perceived by 83.3% of educators and 57% of students. Overall, these challenges underscore the need for improved infrastructure, financial support, training opportunities, and change management strategies to foster effective VR integration in Building Technology education.

Pearson Chi-Square Test

Chi-square	33.386
df	4
P-Value	0.000

Table 10. Chi-Square test results

Interpretation

The results of the Chi-Square test reveals that there is a significant difference between the responses of educators and students on the challenges affecting the effective integration of Virtual Reality (VR) in Building Technology education, as indicated by p-value less than 0.05. Hence, the hypotheses stated in this study is supported.

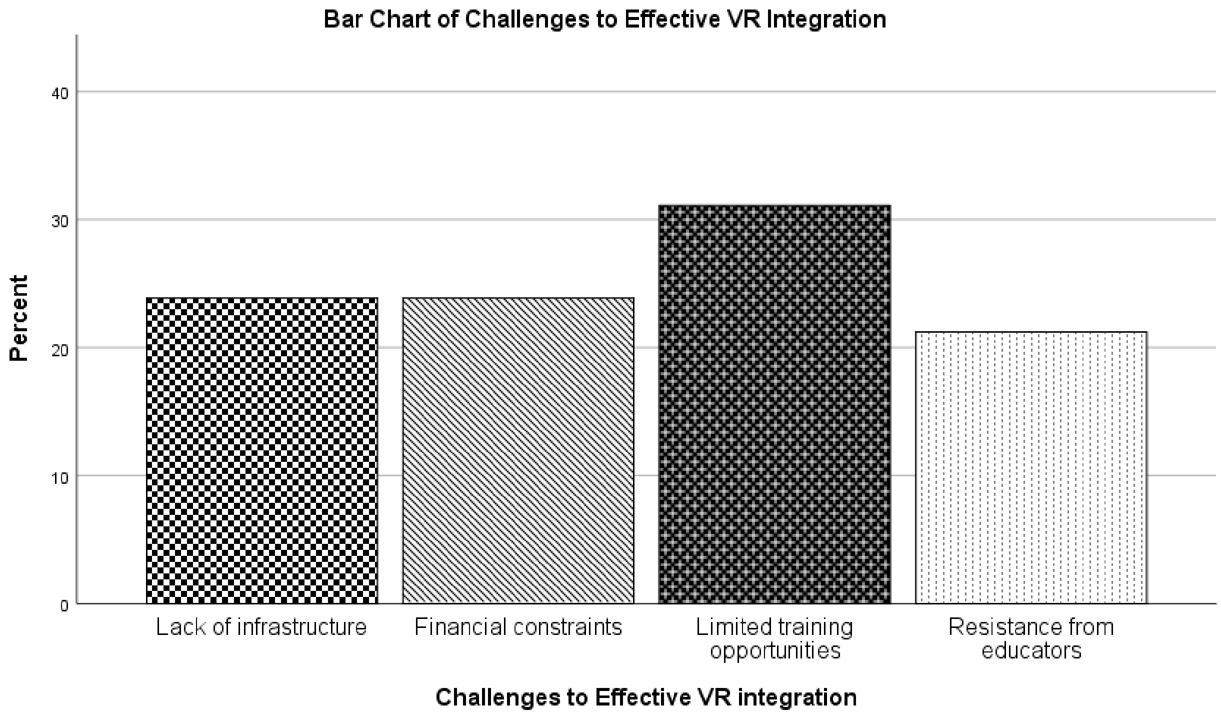

Figure 1. Bar chart of challenges to effective VR integration

Interpretation

The bar chart on Challenges to Effective VR Integration highlights significant obstacles in incorporating virtual reality into building technology education. The most prominent challenge, affecting 30%, is the lack of training opportunities resulting in a dearth of technical expertise, which hampers effective implementation. Financial constraints, accounting for 22%, reflect the high costs associated with acquiring and maintaining VR technology. Additionally, 20% of institutions struggle with inadequate infrastructure, lacking the necessary technological support. Lastly, 18% of educators resist adopting VR due to unfamiliarity or skepticism about its benefits. Addressing these challenges through targeted strategies is essential for enhancing building technology education with VR integration.

Independent Samples T-Test

	t-test for Equality of Means					
	t	df	p-value	Mean Difference	Std. Error Difference	Decision
How familiar are you with the concept of Virtual Reality (VR)?	7.865	133.486	0.000	1.089	0.138	Significant
Have you had any prior experience using Virtual Reality in an educational context?	8.415	158.182	0.000	0.740	0.088	Significant
To what extent are you aware of the potential benefits of integrating Virtual Reality in Building Technology education?	5.420	136.223	0.000	0.746	0.138	Significant
How do you perceive the Relevance of Virtual Reality in addressing practical skills gaps in Building technology?	4.335	121.123	0.000	0.378	0.087	Significant
To what extent is Virtual Reality Used in Your Institution?	2.139	122.430	0.034	0.209	0.098	Significant
How effective do you believe Virtual Reality is in enhancing student engagement in Building Technology education?	9.909	113.000	0.000	0.465	0.047	Significant
In your opinion, what impact does Virtual Reality have on students' practical skills development?	6.661	113.000	0.000	0.395	0.059	Significant
Overall, VR technology is a valuable tool for enhancing building technology education	4.603	113.000	0.000	0.158	0.034	Significant

Table 11. Independent Samples T-Test Results

Interpretation

The results of the Independent Samples T-Test reveal statistically significant differences between the responses of educators and students across all variables, as indicated by p-values less than 0.05. Hence, the hypotheses stated in this study is supported. Participants demonstrated substantial familiarity with VR, with a mean difference of 1.089 ($t = 7.865$, $p = 0.000$). They also reported significant prior experience using VR in educational contexts ($t = 8.415$, $p = 0.000$) and a high level of awareness of its potential benefits for Building Technology education ($t = 5.420$, $p =$

0.000). The relevance of VR in addressing practical skills gaps was perceived as significant (t = 4.335, p = 0.000), though the extent of VR use in institutions showed a smaller but still significant effect (t = 2.139, p = 0.034). Participants acknowledged VR's effectiveness in enhancing student engagement (t = 9.909, p = 0.000) and its positive impact on practical skills development (t = 6.661, p = 0.000). Overall, VR technology was considered a valuable tool for improving Building Technology education, with a mean difference of 0.158 (t = 4.603, p = 0.000). These findings underscore the critical role of VR in enhancing educational outcomes in the field of building technology.

DISCUSSION OF FINDINGS

The data reveals moderate familiarity with Virtual Reality (VR) in building technology education (mean = 2.96), which aligns with previous research that highlights educators' initial exposure to VR, particularly in developing educational environments (Khukalenko et al., 2022). Despite this, its institutional usage remains limited (mean = 2.29), mirroring findings from Khukalenko et al. (2022), who found that many educators rarely use VR due to resource constraints and institutional barriers. However, respondents in this study strongly acknowledged VR's relevance in addressing practical skill gaps (mean = 4.46), a sentiment echoed by Cooper et al. (2019), who noted that VR can simulate real-world scenarios, thereby improving students' practical competencies. The significant impact of VR on student engagement (mean = 4.67) and skill development (mean = 4.72) is also supported by Khukalenko et al. (2022), who found that VR fosters active learning and motivates students. Challenges identified, such as lack of infrastructure, financial constraints, and limited training, are consistent with Khan (2020), who highlighted these barriers as key impediments to VR adoption in classrooms. Furthermore, statistical analysis revealed significant differences between educators' and students' perceptions ($p < 0.05$), which is consistent with Cooper et al. (2019), who observed differing attitudes between educators and students towards VR, likely due to varying exposure and roles. Despite these challenges, the overwhelmingly positive perception of VR's potential (mean = 4.89) aligns with Khukalenko et al. (2022), who affirmed that educators generally view VR as a transformative educational tool. This suggests that while barriers exist, there is a strong belief in VR's ability to revolutionize education, calling for targeted investments in infrastructure, training, and curriculum restructuring to maximize its benefits.

The findings are consistent with existing literature, which emphasizes both the significant potential of VR in education and the barriers impeding its adoption. Addressing these challenges, including infrastructure, funding, and training, is critical to maximizing VR's educational benefits.

Theoretical and Practical Implications

This study is significant for several reasons. Firstly, it fills a crucial gap in the existing literature by investigating the potential of Virtual Reality (VR) in enhancing building technology education in Nigeria. The results offer valuable insights into the utilization of VR for enhancing educational outcomes and preparing students effectively for the building industry. Additionally, the outcomes of this study could serve as guidance for policymakers, educators, and institutional leaders regarding the advantages and challenges associated with VR integration, influencing forthcoming decisions and financial allocations. Policymakers may formulate supportive measures to promote VR adoption in educational settings, while educators can apply these insights to develop more effective curricula.

Moreover, through offering practical suggestions for the implementation of VR, this study has the potential to enhance the standard of building technology education, consequently producing graduates who are better equipped to fulfill industry requirements and contribute to national development. Enhanced educational outcomes can result in a highly skilled workforce, which is imperative for the expansion and sustainability of the construction sector in Nigeria. Furthermore, this research can act as a reference for future studies on the integration of emerging technologies in education, fostering continual enhancement and innovation in teaching and learning methodologies.

CONCLUSION

The integration of VR in Nigerian building technology education presents immense opportunities to bridge the gap between theoretical learning and practical application. While respondents acknowledged VR's transformative potential, limited adoption, stemming from infrastructural deficits, financial challenges, and training gaps, remains a significant hurdle. The study underscores the need for targeted interventions, including increased stakeholder support, strategic investments in VR infrastructure, and capacity-building initiatives for educators. By following the proposed strategy for curriculum integration, investing in technology and infrastructure, providing comprehensive training, and implementing a robust evaluation plan, institutions can effectively enhance their educational offerings through VR. This strategic approach will support the development of students' skills and better prepare them for careers in the building technology field.

Delimitations

This study focused on the integration of VR in building technology education within Nigerian tertiary institutions. The research was limited to a select number of institutions that offer building technology programs. While the study has provided comprehensive recommendations, the findings may not be generalizable to all tertiary institutions in Nigeria due to variations in resources, infrastructure, and institutional policies. Moreover, the study focused on VR as a standalone technology, although it acknowledges that the integration of other emerging technologies (such as Augmented Reality and Artificial Intelligence) could further enhance educational outcomes. The scope of this research was also constrained by time and resource limitations, which may affect the depth and breadth of data collection and analysis.

Recommendations and Implementation Strategy

Based on the study's findings, the following recommendations are proposed and an implementation strategy outlined to assist in the effective implementation of Virtual Reality (VR) in building technology education within Nigerian tertiary institutions.

Recommendations

1. **Policy Recommendations**
    - **Government and Institutional Support**: Allocate funds, grants, and subsidies to support VR adoption in education.
    - **National Standards**: Develop standards for VR integration addressing technology, curriculum, and evaluation.
2. **Institutional Recommendations**
    - **Infrastructure Investment**: Purchase VR hardware, software, and create VR labs.
    - **Professional Development**: Train educators and IT staff in technical and pedagogical VR use.
    - **Collaboration**: Partner with industry stakeholders, technology providers, and institutions for resource sharing and expertise.

Implementation Strategy

1. **Curriculum Integration**
    - **Curriculum Design**: Revise courses to include VR modules enhancing spatial awareness, construction simulations, and other objectives.
    - **Technology Setup**: Acquire VR hardware, establish labs, and ensure technical support.
    - **Stakeholder Engagement**: Collaborate with faculty, industry, and gather student feedback for relevant content.

2. **Training and Professional Development**
    - **Educator Training**: Focus on technical skills (using VR systems) and pedagogical strategies for VR-based teaching.
    - **Continuous Development**: Offer ongoing workshops and updates on VR advancements.
3. **Evaluation Plan**
    - **Metrics**: Measure learning outcomes, student engagement, and educator feedback.
    - **Data Collection**: Use surveys, focus groups, and performance metrics to gather insights.
    - **Improvement**: Regularly report findings and refine strategies based on evaluation results.

This streamlined plan emphasizes key actions to ensure VR's effective adoption in building technology education.

Further Research

Longitudinal Studies: Conduct longitudinal studies to assess the long-term impact of VR on student learning outcomes and career readiness in the building technology field. This research could provide deeper insights into the effectiveness of VR over time.

Comparative Studies: Explore comparative studies between institutions that have integrated VR extensively and those that have not. This research could highlight differences in educational outcomes and identify factors contributing to successful VR integration.

Exploring Emerging Technologies: Investigate the potential of emerging technologies, such as Augmented Reality (AR) and Mixed Reality (MR), in complementing VR and enhancing building technology education further.

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