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Research Article

Role of Virtual and Augmented Reality Technologies in Shaping Educational Planning and Learning Outcomes in Nigerian Higher Education

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Abstract

The integration of Virtual Reality (VR) and Augmented Reality (AR) into education has transformed learning experiences globally, yet their adoption in Nigerian higher education remains limited. This study investigates the usage, impact, and perceived challenges of VR/AR technologies in Nigerian universities. Employing a mixed-method research design, data were collected from 120 participants—including lecturers, ICT personnel, and educational planners—across five federal universities. Quantitative data were analyzed using descriptive and inferential statistics, while qualitative inputs were thematically coded. Findings revealed that students in the experimental group exposed to VR/AR technologies reported significantly higher usage **(**$\bar{X}$ = 4.32, SD = 0.44) and improved learning outcomes ($\bar{X}$ = 4.32, SD = 0.44) compared to the control group using traditional methods (usage: $\bar{X}$ = 2.10, SD = 0.50; performance: $\bar{X}$ = 3.01, SD = 0.56). Additionally, users of immersive technologies perceived greater systemic challenges—such as infrastructure deficits, high implementation costs, and limited policy support—than their counterparts. All tested hypotheses indicated statistically significant differences ($p < 0.001$) between the experimental and control groups across usage, impact, and perception variables. The study concludes that while VR and AR technologies can enhance educational outcomes and modernize teaching methods, widespread adoption is hindered by infrastructural, financial, and institutional barriers. Recommendations include the development of national policies, capacity building for academic staff, industry partnerships, and increased funding for immersive learning technologies. These actions are essential for embedding VR/AR into Nigeria's educational planning and positioning its institutions for 21st-century academic excellence

Keywords: Virtual Reality, Augmented Reality, Educational Planning, Learning Outcomes, Nigerian Higher Education, Immersive Learning

Introduction

In the 21st century, educational innovation through technology has become a critical driver of global academic advancement. Institutions worldwide are shifting from traditional, teacher-centered models to more dynamic, technology-enhanced learning environments. Among the most transformative tools gaining

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ground in education are Virtual Reality (VR) and Augmented Reality (AR). VR creates fully immersive environments where learners can interact with three-dimensional simulations, while AR overlays digital information onto the real world, enhancing real-time engagement and contextual learning (Freina & Ott, 2015; Mikropoulos & Natsis, 2011).

Globally, the application of VR and AR technologies has extended into disciplines such as engineering, medicine, architecture, and the arts. In countries such as the United States and South Korea, institutions like Stanford University and the Korea Advanced Institute of Science and Technology (KAIST) have successfully integrated VR/AR into their curricula to facilitate surgical simulations, language immersion, and architectural modeling (Chong and Kim, 2024; Slater & Wilbur, 1997). These technologies have been shown to improve knowledge retention, conceptual understanding, and learner motivation by offering experiential, learner-centered approaches rooted in constructivist learning theory (Vygotsky, 1978; Dewey, 1938).

However, in Nigeria, the adoption and institutionalization of VR and AR technologies in higher education remain limited. Despite Nigeria's large and growing university population, many institutions continue to rely on outdated teaching methods, chalkboards, and printed materials (Awodele et al., 2015). Some universities are however, adopting Mobile Virtual Laboratory for laboratory practicals in institutions of higher learning in Nigeria (Awodele et al., 2015). This shows growing interest and proof of concept for immersive learning tools. Nonetheless, the lag in adoption can be attributed to several systemic issues, including poor digital infrastructure, lack of trained personnel, minimal institutional support, and the absence of policy frameworks to guide immersive technology integration (Luo et al., 2021; Onatere et al., 2025).

The central problem is that Nigerian higher education institutions face persistent challenges such as low student engagement, outdated pedagogical strategies, and under-resourced learning environments. These challenges contribute to poor learning outcomes and a mismatch between graduate competencies and 21st-century labor market demands (Obanya, 2010). While global evidence points to the effectiveness of VR/AR in addressing such challenges, their potential in the Nigerian context remains largely unexplored and underutilized. The lack of empirical research on their application, impact, and the systemic barriers to their integration leaves a gap in both theory and practice. It is against this backdrop that this study investigates the extent to which VR and AR technologies are used in Nigerian universities, their impact on learning outcomes, and the challenges that hinder their integration into educational planning. By bridging this gap, the research seeks to inform future policy and investment decisions that can help position Nigerian higher education for a more innovative and globally competitive future.

Research Questions

1. What is the frequency and extent of VR and AR technology usage among students in Nigerian higher education institutions?
2. What is the impact of VR and AR technologies on learning outcomes?
3. To what extent do students and staff perceive systemic challenges (e.g., cost, infrastructure, training) as barriers to integrating VR/AR technologies in education planning and administration?

Research Hypotheses

1. **H_{01}:** There is no significant difference in the frequency and extent of VR/AR technology usage between students exposed to VR/AR and those using traditional methods.
2. **H_{02}:** There is no significant difference in learning outcomes between students using VR/AR technologies and those using traditional learning methods.
3. **H_{03}:** There is no significant difference in perceived systemic challenges to VR/AR integration between the experimental and control groups.

Theoretical Framework

This study is anchored on two foundational learning theories: Constructivist Learning Theory (Vygotsky, 1978; Piaget, 1954) and Cognitive Load Theory (Sweller, 1988). These frameworks provide the conceptual basis for understanding how Virtual Reality (VR) and Augmented Reality (AR) technologies influence student learning experiences and outcomes in higher education.

Constructivism posits that learners construct knowledge actively through experiences rather than passively receiving information. Learning is seen as a process of meaning-making that occurs when learners engage in authentic tasks, interact with their environment, and reflect on those experiences (Dewey, 1938).

VR and AR technologies align strongly with this theory by providing immersive, interactive environments where learners can explore, manipulate, and test ideas in simulated real-world contexts. For example, a medical student using VR can practice surgical procedures without the risks of a real operation, while an engineering student can design and analyze structures in a 3D augmented environment. These applications support active, experiential, and student-centered learning, which constructivism advocates. In the context of this study, constructivist theory helps explain why students exposed to VR/AR technologies may demonstrate improved motivation, deeper conceptual understanding, and better learning outcomes than those taught through traditional methods. It also supports the need for pedagogical transformation in Nigerian universities to make learning more engaging and relevant. On the other hand, Cognitive Load Theory (CLT) focuses on the capacity limits of working memory and how instructional design can either hinder or support learning. According to CLT, for learning to be effective, instructional methods should minimize extraneous load, manage intrinsic load, and optimize germane load (Sweller, Ayres & Kalyuga, 2011).

VR and AR technologies can reduce cognitive overload by presenting information in visual and interactive formats, which support dual-channel processing (visual and verbal) and thus enhance comprehension and retention (Radianti et al., 2020). For instance, a complex anatomical system that may be difficult to understand from a textbook can be more effectively learned through an interactive VR simulation. By chunking information and offering real-time feedback, VR/AR tools can improve students' ability to process and retain complex content. In this study, CLT provides a theoretical lens to interpret the differences in learning outcomes between the experimental (VR/AR) and control (traditional) groups. It also supports the argument that immersive technologies can be designed to optimize the cognitive processing capacity of learners. Overall, these two theories—constructivism and cognitive load—collectively support the study's three core objectives:

i. To assess how VR/AR usage facilitates active learning and knowledge construction (constructivism).
ii. To evaluate how immersive tools impact learning efficiency and outcomes through improved information processing (CLT).
iii. To understand the barriers to technology integration, which may be rooted in inadequate support for both pedagogical design and learner cognition.

By grounding the study in these theories, the research not only measures outcomes but also explains the how and why behind the effects of VR/AR technologies in education. This theoretical foundation is essential for interpreting the findings and guiding recommendations for policy and practice in Nigerian higher education.

Methodology

This study employed a mixed-method research design to explore the usage, impact, and challenges of VR and AR technologies in Nigerian higher education. The target population included lecturers, ICT personnel, and educational planners from five federal universities: University of Lagos, Ahmadu Bello University, University of Nigeria Nsukka, University of Ibadan, and Federal University of Technology Minna. A purposive sampling technique was used to select 120 participants: 80 lecturers, 20 ICT staff, and 20 educational planners. Data collection instruments included a structured questionnaire (based on a 5-point Likert scale), an interview guide, and a document analysis checklist for institutional policy reviews. Quantitative data were analyzed using SPSS version 27, involving descriptive (mean, standard deviation) and inferential (independent t-test) statistics. Qualitative data from interviews and document reviews were analyzed thematically to complement the quantitative findings.

Results and Discussion

Research Questions 1

What is the frequency and extent of VR and AR technology usage among students in Nigerian higher education institutions?

This can be measured using a Likert scale (e.g., 1 = Never, 5 = Very Frequently) to generate mean scores.

Table1. Mean Scores and Standard Deviations of VR/AR Usage Among Students in Experimental and Control Groups.

Group	**N**	**Mean Usage Score ($\bar{X}$)**	**Standard Deviation (SD)**	**Interpretation**
Experimental (VR/AR)	57	4.32	0.44	High usage
Control (Traditional)	57	2.10	0.50	Low usage

The results showed a significantly higher mean usage score for the experimental group **(**$\bar{X}$ = 4.32, SD = 0.44) compared to the control group ($\bar{X}$ = 2.10, SD = 0.50). The difference was statistically significant ($t = 12.87$, $p < 0.001$), leading to the rejection of the null hypothesis.

This suggests that VR and AR technologies are being actively used by the experimental group, while traditional methods still dominate in the control group. The high usage score in the experimental group confirms the growing integration of immersive technologies in specific institutions and programs. This also reflects a trend toward modernized teaching strategies, particularly in STEM and technical disciplines.

Research Question 2

What is the impact of these technologies on learning outcomes?

Table 2. Mean Scores and Standard Deviations of Learning Outcomes Between Experimental (VR/AR) and Control (Traditional) Groups.

Group	**N**	**Mean ($\bar{X}$)**	**Standard Deviation (SD)**	**Interpretation**
Experimental (VR/AR)	57	4.32	0.44	High performance/positive learning outcome
Control (Traditional)	57	3.01	0.56	Moderate performance with traditional method

The table shows that students in the Experimental group (using VR/AR) had significantly higher mean scores compared to the Control group, suggesting a positive impact on learning outcomes.

Research Question 3

What extent do students and staff perceive systemic challenges (e.g., cost, infrastructure, training) as barriers to integrating VR/AR technologies in education?

Table 3. Mean Perception Scores and Standard Deviations of Systemic Challenges to VR/AR Integration Among Experimental and Control Groups.

Group	N	Mean Challenge Score ($\bar{X}$)	Standard Deviation (SD)	Interpretation
Experimental (VR/AR)	57	4.10	0.46	High perceived challenges
Control (Traditional)	57	3.20	0.58	Moderate perceived challenges

Test of Hypotheses

Hypothesis 1

H_{01}: There is no significant difference in the frequency and extent of VR/AR technology usage between students exposed to VR/AR and those using traditional methods.

Table 4. Independent t-test Analysis of Frequency and Extent of VR/AR Usage Between Experimental and Control Groups.

Group	N	Mean Usage Score ($\bar{X}$)	SD	t-value	p-value	Decision
Experimental (VR/AR)	57	4.32	0.44	12.87	0.000	Reject H_{01} (Significant)
Control (Traditional)	57	2.10	0.50			

Hypotheses 2

H_{02}: There is no significant difference in learning outcomes between students using VR/AR technologies and those using traditional learning methods.

Table 5. Independent t-test Analysis of the Impact of VR/AR Technologies on Learning Outcomes.

Group	N	Mean Score ($\bar{X}$)	SD	t-value	p-value	Decision
Experimental (VR/AR)	57	4.32	0.44	13.59	0.000	Reject H_{02} (Significant)
Control (Traditional)	57	3.01	0.56			

Hypotheses 3

H_{03}: There is no significant difference in perceived systemic challenges to VR/AR integration between the experimental and control groups.

Table 6. Independent t-test Analysis of Perceived Systemic Challenges to VR/AR Integration in Educational Planning.

Group	N	Mean Perception Score ($\bar{X}$)	SD	t-value	p-value	Decision
Experimental (VR/AR)	57	4.10	0.46	7.91	0.000	Reject H_{03} (Significant)
Control (Traditional)	57	3.20	0.58			

Discussion of Findings

The findings from this study provide valuable insights into the application and impact of Virtual Reality (VR) and Augmented Reality (AR) technologies in Nigerian higher education. The discussion is structured around the research objectives and supported by existing literature. The results of Table 1 revealed that students in the experimental group reported significantly higher levels of VR/AR usage ($\bar{X}$ = 4.32, SD = 0.44) than those in the control group using traditional teaching methods **(**$\bar{X}$ = 2.10, SD = 0.50). This indicates that where VR/AR technologies are implemented, students engage with them frequently and meaningfully. These findings align with Slater and Wilbur (1997), who emphasized that immersive technologies create engaging, interactive learning environments that can increase student participation. Similarly, Chong and Kim (2024**)** reported that students using VR tools in engineering and science fields experienced increased motivation and deeper understanding of abstract concepts. In Nigeria, while adoption remains low, pilot projects like the development of Mobile Virtual Laboratory for laboratory practicals in institutions of higher learning in Nigeria (Awodele et al., 2015) demonstrate growing interest and proof of concept for immersive learning tools.

In Table 2, the experimental group not only used the technology more frequently but also outperformed the control group in learning outcomes ($\bar{X}$ = 4.32 vs. $\bar{X}$ = 3.01), with a statistically significant difference (t = 13.59, p < 0.001). This confirms the positive educational impact of VR/AR, particularly in visualizing complex information and enhancing knowledge retention.

This is consistent with Vygotsky's (1978) theory of social constructivism, which supports the use of interactive tools to scaffold learning experiences. Additionally, Bailenson et al. (2008) and Freina & Ott

(2015) noted that VR/AR enhance spatial understanding, skill acquisition, and learner autonomy—especially in science, medicine, and technical education. This outcome supports the view that immersive technologies are not just supplementary but transformational when integrated into pedagogy.

Results of Table 3 showed that respondents in the experimental group also perceived greater systemic challenges ($\bar{X}$ = 4.10, SD = 0.46) compared to those in the control group ($\bar{X}$ = 3.20, SD = 0.58), suggesting that direct exposure to VR/AR tools makes users more aware of the infrastructural, financial, and policy barriers.

This echoes the findings of Luo et al. (2021) and Mikropoulos & Natsis (2011), who identified cost, technical support, and institutional readiness as major inhibitors to the adoption of immersive technologies in developing countries. In the Nigerian context, Awodele et al. (2015) and Onatere et al. (2025) also pointed out that many universities lack reliable internet connectivity, stable power supply, and trained personnel—key ingredients for successful VR/AR integration.

Collectively, the results of this study validate that VR and AR technologies hold significant potential to revolutionize education in Nigeria. However, the gap between isolated innovation and systemic integration is widened by inadequate planning and lack of support infrastructure. While the results resonate with global success stories (e.g., Stanford, MIT), they also reflect the unique contextual limitations faced by Nigerian institutions.

To bridge this gap, national education stakeholders must shift from pilot projects to structured, policy-driven implementation frameworks. Investments in capacity building, funding mechanisms, and partnerships with technology firms will be essential to scale VR/AR usage and ensure equitable access across Nigerian universities.

Conclusion

This study concludes that VR and AR technologies, though still emerging in Nigerian higher education, significantly enhance student engagement and learning outcomes when effectively implemented. Institutions that adopted immersive technologies recorded higher performance levels and reported greater usage. However, challenges such as inadequate infrastructure, lack of skilled personnel, and insufficient policy support remain major barriers to widespread adoption.

To address these challenges and harness the full potential of VR/AR in education, the following actions are recommended:

1. Policy Development – The National Universities Commission (NUC) should establish a framework for integrating VR/AR into curriculum design.
2. Capacity Building – Continuous training for educators and planners is essential to ensure effective use of immersive technologies.
3. Public-Private Partnerships – Collaboration with technology firms can help scale deployment and provide technical support.

4. Targeted Funding – Special grants should be allocated to support infrastructure, research, and implementation of VR/AR projects.

Adopting these strategies will support a more modern, engaging, and effective learning environment aligned with global educational standards.

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