IMPACT OF VIRTUAL LEARNING ON STUDENT ENGAGEMENT AND LEARNING OUTCOMES IN STEM EDUCATION AT TERTIARY INSTITUTIONS: A STUDY OF KWARA STATE UNIVERSITY

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Abstract
With the rapid advancement of technology, virtual learning has become increasingly prevalent in tertiary education, particularly in STEM (Science, Technology, Engineering, and Mathematics) disciplines. This study examines the impact of virtual learning on student engagement and learning outcomes, using Kwara State University as a case study. A quantitative approach was employed, gathering data through web-based surveys from students enrolled in STEM courses. The study investigates the relationship between virtual learning activities, student engagement, and learning outcomes. Statistical methods, including descriptive statistics and linear regression, were used to analyze the data. Findings reveal a positive correlation between virtual learning activities and student engagement, though no significant impact was observed on learning outcomes. The study concludes that while virtual learning can enhance engagement, learning outcomes may be influenced more by factors such as teaching methods, instructional quality, and student motivation.

Keywords: Virtual learning, STEM education, Student engagement, Learning outcome, Tertiary education

1.0 Introduction
The effect of COVID-19 necessitates social distancing across the global space. This challenge underscored the need to explore alternative methods for maintaining human contact, particularly in professional settings. Rapid technological advancements in the post-pandemic era have emerged as a key solution to mitigate the effects of social distancing and the barriers to human interaction it created. Consequently, exploring and utilising virtual spaces to facilitate human contact and interactions become essential (Sato *et al.,* 2020). This shift has prompted an evaluation of digital environments for supporting social interactions, professional collaborations, and educational activities (Sato *et al.,* 2023; Sigal and Ron, 2023). During the pandemic, the accelerated adoption of technology across various sectors was crucial for maintaining physical distance and controlling the virus's spread. This technological adoption fundamentally changed how people interact, work, and learn (Alghamdi and Alghamdi, 2022; Jose and Carmen, 2021). Virtual spaces become vital in bridging the gap created by physical separation, offering versatile and dynamic environments for engagement without geographical constraints.

A significant impact of technological evolution is the enhancement of social contact through virtual means. Platforms and tools like video conferencing applications, virtual reality environments, and social media have become integral in maintaining human connections (Bhardwaj, Bhardwaj, and Chaudhary, 2023). The post-pandemic era has seen a surge in demand for virtual learning and technological innovations in teleconferencing (Stoyanov *et al.,* 2022). This led to the emergence of applications like Zoom, Moodle, Microsoft Teams, Google Meet, and others. These technologies enhance the usability of virtual means to transmit information and support the teaching-learning process amidst social distancing constraints. They allow real-time interactions, meetings, and social activities despite physical distance. The education sector, in particular, has been profoundly affected by this shift to virtual spaces (Ascione, 2023; Alshehri, 2024; Vergara, Fernández-Arias, Extremera, Dávila, and Rubio, 2022; Obla and Ukabi, 2021). Traditional classrooms have transformed into hybrid or fully online models, leveraging technology to continue the teaching-learning process. Virtual classrooms, online courses, and

digital collaboration tools have become essential, offering new opportunities for interactive and personalized learning.

Studies have examined the correlation between virtual learning and various factors in higher education. Vergara *et al.* (2022) explored how the education sector has benefited from the ICT-driven revolution, which has introduced new tools and teaching methods that were not available a few decades ago. According to them, the technological shift led to the development of virtual laboratories (VLs) using virtual reality (VR), increasingly utilized to enhance the teaching and learning process across diverse training activities. Their study, involving 420 engineering students from Spanish and Portuguese universities, assessed different parameters in various VLs designed by the authors. The findings revealed that VR-based VLs are widely accepted and sought after by students, who also consider real laboratories (RLs) essential for face-to-face instruction.

Similarly, Obla and Ukabi (2021) found that learning in virtual spaces plays a significant role in developing pro-technology and pro-internet attitudes among students. Their research focused on sustainable strategies for achieving inclusive and tension-free learning during the COVID-19 pandemic. They highlighted that digital materials make the pedagogical approach more enjoyable, engaging, innovative, and inclusive. Their study examined whether virtual spaces for instructional delivery offer sustainable and inclusive methods for educating learners during and after the pandemic. By employing a theory-based conceptual approach and an inside-outside perspective, they addressed the Nigerian context, where virtual learning initially faced skepticism due to operational and policy challenges. They identified positive potential in virtual spaces and challenged earlier studies that failed to address uncertainty variables.

In contrast, Alshehri (2024) investigated the impact of digital education on modern educational institutions through existing literature and materials from public, educational, and expert sources. He argued that digital learning allows students to use a broader range of materials, thereby enhancing communication and study opportunities beyond the limitations of traditional classroom resources. Alshehri emphasised that while a positive attitude and motivation can improve academic performance and engagement, digital education also presents various pros and cons in the teaching environment and affects different beneficiaries.

The above perspectives align with Constructivist Learning Theory, as articulated by Jean Piaget (1896-1980) and Lev Vygotsky (1896 – 1934). Jean Piaget's Cognitive Development Theory emphasises how learners actively construct their understanding and knowledge through experience and reflection (Cherry, 2023). This concept is particularly relevant to virtual learning environments, where students interact with digital tools and resources. Such interactions facilitate active learning and cognitive development by enabling students to engage in interactive simulations and problem-solving tasks, thus helping them build and organise their knowledge (Darling-Hammond, Flook, Cook-Harvey, Barron, and Osher, 2019). This approach can significantly influence both student engagement and learning outcomes in STEM (Science, Technology, Engineering, and Mathematics) education.

Lev Vygotsky's Social Constructivism further complements this view by focusing on the social aspects of learning and the role of interaction with more knowledgeable others, such as peers and instructors, in cognitive development (Mcleod, 2024). Vygotsky's concept of the "Zone of Proximal Development" (ZPD) underscores that learning occurs through guided interaction and support. This theory applies to virtual learning environments that often feature collaborative tools and online forums, allowing students to engage in meaningful interactions with peers and instructors (Picciano, 2017). Thus, Vygotsky's theory highlights how social interactions and collaborative learning in virtual settings can enhance both engagement and learning outcomes.

Despite these advancements, virtual learning presents challenges such as ensuring equitable access to technology, maintaining student engagement, and addressing the digital divide. These issues impact student engagement and learning outcomes in tertiary institutions, including Kwara State University (KWASU) in Malete, Kwara State, Nigeria. Established in 2009, KWASU offers a range of programs from STEM to non-STEM disciplines, reflecting the broader shift toward integrating virtual learning in higher education. With the rapid advancement of technology, virtual learning especially the introduction Learning Management System (SMS) become increasingly prevalent in Kwasu, particularly in STEM disciplines. Educators have adapted their strategies to effectively use virtual tools and create engaging online learning environments. Given the existing studies on the nexus of the technological driven virtual learning environment and classroom engagement (Alshehri, 2024, Obla and Ukabi, 2021, Bhardwaj, Bhardwaj, and Chaudhary, 2023, Stoyanov *et al.,* 2022), only few literatures examine the impact of virtual learning on student engagement and learning outcomes in STEM education in Nigeria, especially in KWASU. Hence, this study examines the impact of virtual learning on student engagement and learning outcomes in STEM education, focusing on Kwara State University.

2.0 Purpose of the Research

This study aims to assess the impact of virtual learning on student engagement and learning outcomes in STEM education, focusing on Kwara State University as a case study. Hence the study will provide answers to the following questions:

1. How does virtual learning impact students' engagement in the STEM education process at Kwara State University?
2. How does virtual learning influence learning outcomes in STEM education at Kwara State University?

3.0 Hypothesis

$H0_1$: There is no significant relationship between virtual learning activities and students' engagement in STEM education in KWASU

$H0_2$: There is no significant relationship between virtual learning activities and learning outcomes in STEM education in KWASU

4.0 Methods and Materials

The research employed a quantitative approach using web surveys and a descriptive method to gather comprehensive data from both primary and secondary sources. Quantitative data was collected through surveys administered to students enrolled in STEM courses at Kwara State University, focusing on their virtual learning engagement and learning outcomes in virtual learning environments. The entire population of the study comprised 150 students in the STEM faculties at the university. Eighty students across the academic levels in the university were randomly selected, representing 53.3% of the entire population. Consequently, 80 questionnaires were sent to the respondents; only 63 (78.75%) of these were returned, and 60 (75%) were valid for analysis. Key variables examined included virtual learning activities, students' engagement levels, and learning outcomes in STEM courses in virtual learning environments. Descriptive analysis was employed for demographic data, while linear regression analysis was conducted to find the relationship between virtual learning activities and students' engagement in virtual learning and learning outcomes in STEM education at KWASU. The demographic details of the respondents are presented in Table 1.

4.1 Table 1: Demographic Data

Variables	Items	Frequency	Percentage
Gender	Male	31	51.7
	Female	29	48.3
Age	Below 18	11	18.3
	18-25	45	75
	26-30	3	5
	Above 30	1	1.7
Academic Year	100	19	31.7
	200	30	50
	300	4	6.7
	400	6	10
	400 and above	1	1.7
Virtual Platforms being used	Google Meet	17	28.3
	Moodle	5	8.3
	Zoom	20	33.3
	Others	18	30

Source: Author's Fieldwork, 2024

The above reflects the demographic details of the respondents. It shows that 51.7% of the respondents are male, while 48.3% are female.

Additionally, 18.3% of them are below the age of 18, 75% are between the ages of 18 and 25, 5% are between 26 and 30, and the remaining 1.7% are above 30 years old.

Similarly, 31.7% are in the 100 level, 50% are in the 200 level, 6.7% are in the 300 level, 10% are in the 400 level, and 1.7% are in classes above the 400 level.

Regarding the virtual platforms being used, 28.3% of the respondents used Google Meet, 8.3% used Moodle, 33.3% used Zoom, and the remaining 30% used other platforms.

5.0 Findings

5.1 Test of Hypotheses/Results

This section presents the analysis of the hypotheses set for the study. The hypotheses were tested using linear regression model.

$H0_1$: There is no significant relationship between virtual learning activities and students' engagement in STEM education in KWASU

5.1.1 Table 2: Regression Analysis of the relationship between Students' Virtual Engagement and Virtual Learning Activities

Variables	Beta (β)	T	Sig.	R^2	Adj. R^2	F	P
(Constant)	3.900	10.618	.000				
Students Virtual Engagement	-.407	.470	.000	.204	.190	14.837	.000[b]
Dep. Variable: Virtual Learning Activities Ind. Variable: Students' Virtual Engagement DF (F-Statistics) =59							

Source: Author's Fieldwork, 2024 y = a + bx

Virtual Learning Activities = a + b (Students' Virtual Engagement)
Virtual Learning Activities = 3.900 + (-0.407) (Students' Virtual Engagement)
The above table shows that there is a significant relationship between Virtual Learning Activities and Students' Virtual Engagement. The results indicate a significant relationship between Virtual Learning Activities and Virtual Learning Activities with $p < 0.001$, $R^2 = 0.204$, $F = 14.837$. The results further show that Students' Virtual Engagement accounts for about 20.4% of the Virtual Learning Activities. The F-statistic demonstrates the suitability of the regression model. Since sig value (0.000) < p-value (0.05), hypothesis one is rejected, concluding that there is a significant relationship between Virtual Learning Activities and Students' Virtual Engagement.
$H0_2$: There is no significant relationship between virtual learning activities and learning outcomes in STEM education in KWASU

5.1.2 Regression Analysis of the Relationship Between Learning Outcome and Virtual Learning Activities

Variables	Beta (β)	T	Sig.	R^2	Adj. R^2	F	P
(Constant)	2.915	4.299	.000				
Learning Outcome	-.061	-.547	.589	.005	-.012	0.299	.586[b]
Dep. Variable: Virtual Learning Activities Ind. Variable: Learning Outcome DF (F-Statistics) =59							

Source: Author's Fieldwork, 2024 y = a + bx
Virtual Learning Activities = a + b (Learning Outcome)
Virtual Learning Activities = 2.915+ (-.061) (Learning Outcome)
The table above shows that there is no significant relationship between virtual learning activities and learning outcomes. With $p < 0.001$, $R^2 = 0.005$, and $F = 0.299$, the results indicate that virtual learning activities account for about 0.5% of the learning outcomes. The F-statistic shows a fair suitability of the regression model. Since sig value (0.589) > p-value (0.05), hypothesis two is accepted, concluding that there is no significant relationship between virtual learning activities

and learning outcomes.

6.0 Discussion

Hypothesis one reveals a significant relationship between virtual learning activities and students' engagement in STEM education at KWASU. The reason for this could be due to its flexibility and convenience compared to face-to-face classroom interactions. Virtual learning allows students to access course materials and participate in classes from any location, as well as learn at their own pace. This conclusion aligns with the study conducted by Vergara et al. (2022), which found that VR-based VLs are widely accepted and demanded by students, who also consider real laboratories (RLs) necessary for face-to-face teaching. Also, Obla and Ukabi (2021) found that learning in a virtual space for pro-technology and pro-Internet generation contributes significantly to developing their inherent domains.

The second hypothesis indicates no significant relationship between virtual learning activities and learning outcomes. This lack of correlation could be attributed to other distracting intervening variables present in the virtual learning environment. According to Alshehri (2024), digital learning allows students to communicate and study using a broader range of materials. He suggests that students' academic performance and engagement in active learning improve with a positive attitude and motivation. However, in the absence of such positive factors, learning outcomes may suffer due to the various pros and cons of the teaching environment and its impact on different beneficiaries (Usman and Madudili, 2019).

Therefore, while the study confirms the relationship between virtual learning activities and students' engagement in STEM education at KWASU, given its flexibility and convenience compared to face-to-face classroom interactions, as noted earlier, there is no positive correlation between virtual learning activities and learning outcomes.

7.0 Conclusion

The study aimed to assess the relationship between virtual learning, student engagement, and learning outcomes in STEM education at tertiary institutions with a focus on KWASU. The post-pandemic era has highlighted the need to explore virtual spaces due to technological advancements, leading to the use of teleconferencing tools for knowledge transmission. The study employs Constructivist Learning Theory, as articulated by Jean Piaget and Lev Vygotsky, to explain the influence of the learning environment on student engagement and learning outcomes. Using quantitative methods to gather data, the study found a positive correlation between virtual learning activities and student engagement in STEM education. However, it also revealed that virtual learning activities do not necessarily correlate with student learning outcomes at KWASU. Consequently, the study concludes that learning outcomes are influenced by other intervening variables.

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ASSESSING PRIMARY SCHOOL TEACHERS' FAMILIARITY AND READINESS TO LEVERAGE AI TOOLS FOR IMPROVED TEACHING IN GUSAU, ZAMFARA.

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Abstract
This study investigates primary school teachers' familiarity and readiness to integrate artificial intelligence (AI) tools into their teaching practices in Gusau, Zamfara. A mixed-methods approach was employed, utilizing surveys and interviews to gather data from a sample of primary school teachers. The survey assessed teachers' confidence, skills, and perceptions regarding AI tools, while interviews provided deeper insights into their experiences and challenges. Findings indicate that while teachers moderately agree on their confidence and skills related to AI tools, there is a notable gap in their readiness to implement these technologies effectively. The mean scores for statements regarding their ability to select and experiment with AI applications were below the threshold for confidence. The results highlight the necessity for continuous professional development programs focused on AI literacy to enhance teachers' capabilities. Recommendations include targeted training sessions and resources to support teachers in integrating AI into their pedagogical practices, ultimately aiming to improve student engagement and learning outcomes. Addressing the identified gaps in AI readiness among teachers is essential for the successful integration of AI in primary education.

Keywords: Artificial Intelligence; Familiarity; Readiness; Evaluation

Introduction
Instructors play a pivotal role in the instructional process, particularly when introducing new concepts and subjects to learners. As the foundations of educational institutions evolve, there is an increasing necessity for innovation to bridge the gap between outdated teaching strategies and the dynamic needs of contemporary students. Encouraging a progressive dialogue about the interplay between technology—specifically artificial intelligence (AI)—and education, while considering both the threats and opportunities presented, will foster significant advancements in modern curricula and learning environments (Chen, Zou, Xie, & Cheng, 2021).

Artificial intelligence encompasses the capacity of machines to learn and perform tasks typically associated with human reasoning and interaction with the environment (Russell & Norvig, 2010). AI-powered tools can gather and analyze data from their surroundings, yielding adaptive, context-specific outputs. Various analytical approaches, including machine learning, natural language processing, and deep learning, are commonly employed in AI applications (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019). AI is a central component of the fourth educational revolution, driving technological innovation that transforms economies and societies alike (Hwang, Xie, Wah, & Gašević, 2020).

AI studies intelligent machines capable of acquiring knowledge, communicating, and reasoning.