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Impact of Technology on Physics Education in North Central Nigerian Colleges of Education

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Abstract

This study evaluated the efficacy of technology-enhanced learning (TEL) tools in improving Physics education outcomes within Colleges of Education in North Central Nigeria. Specifically, it examined the effects of technology integration on students' academic achievement, engagement, and motivation, while also identifying effective pedagogical strategies for classroom implementation. A quasi-experimental pretest-posttest non-equivalent control group design was employed. The study population comprised 5,107 NCE Physics students, from which a sample of 350 was selected using a multistage sampling technique guided by the Krejcie and Morgan (1970) sample size determination model. Intact classes were assigned to experimental and control groups. Data were collected using two validated instruments: the Physics Performance Test (PPT) and the Impact of Technology on Physics Education (ITPE) questionnaire. Reliability indices were established using Kuder-Richardson (KR-20) and Cronbach's alpha coefficients. Descriptive statistics (mean and standard deviation) were used to address research questions, while inferential analyses, including independent samples t-test and multiple regression, were conducted at a 0.05 significance level. Findings indicate that students exposed to TEL interventions achieved significantly higher academic performance than their counterparts under conventional instruction. Furthermore, technology integration exerted a statistically significant positive effect on engagement and motivation, explaining approximately 28% of the observed variance. Effective integration strategies identified include robust institutional support, adequate ICT infrastructure, structured lesson design, deployment of virtual laboratories and simulations, and adoption of student-centered digital pedagogies. The study concludes that TEL significantly enhances learning outcomes in Physics and recommends sustained investment in infrastructure, continuous professional development for lecturers, and systematic curriculum-level integration of digital technologies.

Keywords

Technology,
Achievement,
Physics Education,
Engagement,
Motivation

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Introduction

Physics education has undergone significant transformations in recent years, driven by the rapid advancement of technology. The integration of technology in physics classrooms has opened up new avenues for teaching and learning, enabling students to explore complex concepts in innovative and interactive ways. Technology-enhanced learning tools, such as simulations, virtual labs, and multimedia resources, have become increasingly popular in physics education, offering a range of benefits for students and educators alike.

These technological advancements have the potential to revolutionize the way physics is taught and learned, making it more engaging, accessible, and effective. However, the impact of technology on physics education is a complex issue, and there is a need to investigate its effects on student learning outcomes, engagement, and overall educational experience.

Physics is a cornerstone of science and technology, playing a pivotal role in the economic and technological advancement of any society. As a discipline, Physics fosters critical thinking, problem-solving, and innovation, which are essential for producing a scientifically literate society capable of meeting 21st-century challenges (Jegede & Okebukola, 2017). In Nigeria, the teaching and learning of Physics are largely facilitated in Colleges of Education, where prospective science teachers are trained to handle the subject at secondary education levels.

This study aims to explore the impact of technology on physics education, with a focus on student learning outcomes, engagement, and motivation. By examining the role of

technology in physics education, this research seeks to provide insights into the effective integration of technology in physics classrooms, and to identify best practices for educators and policymakers.

Some potential benefits of technology integration in physics education include. Enhanced student engagement and motivation, Improved understanding and retention of complex concepts, Increased accessibility and flexibility in learning, Personalized learning experiences tailored to individual needs, Development of essential skills in critical thinking, problem-solving, and collaboration. By exploring the impact of technology on physics education, this study aims to contribute to the ongoing conversation about the future of physics education and the role of technology in shaping the learning experiences of students.

Problem Statement

Despite the increasing integration of technology in physics education, there is a lack of comprehensive understanding about its impact on student learning outcomes, engagement, and motivation. Physics education faces unique challenges, such as complex abstract concepts, mathematical rigor, and laboratory experimentation, which can be daunting for many students. The effective integration of technology has the potential to address these challenges, but there is a need to investigate:

How technology-enhanced learning tools (e.g., simulations, virtual labs, multimedia resources) affect student understanding and retention of physics concepts. The impact of technology on student engagement, motivation, and participation in physics classes. The role of technology in developing essential skills, such as critical thinking, problem-solving, and collaboration, in physics education.

This study aims to provide insights into the effective integration of technology in physics education, informing educators, policymakers, and researchers about the potential benefits and challenges of technology-enhanced learning in physics. The findings will contribute to the development of evidence-based practices and policies for technology integration in physics education, ultimately enhancing student learning outcomes and experiences.

Objectives of the Study

The general objective is to investigate the impact of technology on physics education in north central Nigerian colleges of education. The specific objectives are to:

- i. Examine the impact of technology-enhanced learning tools on students' academic achievement in Physics
- ii. Determine the effect of technology integration on students' engagement and motivation in Physics classes
- iii. Identify effective strategies for integrating technology into the teaching and learning of Physics

Research Question

- i. What is the impact of technology-enhanced learning tools on students' academic achievement in Physics?
- ii. What is the effect of technology integration on students' engagement and motivation in Physics classes?
- iii. What are the effective strategies for integrating technology into the teaching and learning of Physics?

Hypothesis

Ho1: There is no significant difference in the academic achievement of students taught Physics using technology-enhanced learning tools and those taught using the traditional teaching method.

Ho2: There is no significant difference in the level of engagement and motivation between students taught Physics using technology-enhanced instruction and those taught using the traditional teaching method.

Literature Review

The integration of technology in physics education has been a topic of interest for researchers and educators in recent years. With the rapid advancement of technology, various tools and resources have become available to support teaching and learning in physics. This literature review aims to synthesize the existing research on the impact of technology on physics education, focusing on student learning outcomes, engagement, and motivation.

Numerous studies have investigated the impact of technology on student learning outcomes in physics. Research has shown that technology-enhanced learning can improve student understanding and retention of physics concepts (Hake, 1998; Wieman & Perkins, 2005). Simulations, in particular, have been found to be effective in promoting conceptual understanding and reducing misconceptions (Zacharia & Olympiou, 2011).

Technology integration has also been found to have a positive impact on student engagement and motivation in physics. Interactive simulations and games can increase student interest and enjoyment in learning physics (Shute, 2008). Additionally, technology-enhanced learning can provide opportunities for students to take ownership of their learning, promoting autonomy and self-directed learning (Kearns & Grant, 2010).

Research has identified several effective strategies for integrating technology in

physics education. These include: - Using simulations and virtual labs: Simulations and virtual labs can provide students with interactive and immersive learning experiences, promoting deeper understanding and engagement (Zacharia & Olympiou, 2011). - Blending technology with traditional teaching methods: A blended approach can help to balance the benefits of technology-enhanced learning with the need for hands-on experimentation and face-to-face interaction (Garrison & Kanuka, 2004). - Providing teacher training and support: Teachers need training and support to effectively integrate technology in their teaching practices (Koehler & Mishra, 2009).

While technology integration has the potential to enhance physics education, there are also challenges and limitations to consider. These include: Technical issues: Technical problems can disrupt the learning experience and create frustration for students and teachers (Keengwe & Anyanwu, 2013). Equity and access: Not all students have equal access to technology, which can create disparities in learning opportunities (Attewell, 2001). Teacher resistance Some teachers may be resistant to integrating technology in their teaching practices, which can limit the effectiveness of technology-enhanced learning (Ertmer, 2005).

The literature review highlights the potential benefits of technology integration in physics education, including improved student learning outcomes, increased engagement and motivation, and enhanced autonomy and self-directed learning. However, it also notes the importance of effective strategies for technology integration, teacher training and support, and addressing challenges and limitations. Further research is needed to

explore the optimal ways to integrate technology in physics education and to address the complexities of technology-enhanced learning.

Methodology

The study was conducted in North Central Nigeria (Middle Belt), comprising Benue, Kogi, Kwara, Nasarawa, Niger, Plateau States, and the Federal Capital Territory (FCT), Abuja. The region hosts several federal and state Colleges of Education with varying levels of technological infrastructure, making it suitable for investigating technology integration in physics instruction. Geographically, the region extends from the border with Cameroon in the east to the Republic of Benin in the west, and is situated around latitude 10° 19'60" N and longitude 7° 45' 0" E.

This study employed a quasi-experimental pretest-posttest non-equivalent control group design to examine the impact of technology on physics education in North Central Nigerian Colleges of Education. The design was appropriate because intact classes were used, making random assignment impracticable while allowing comparison between experimental and control groups.

The population consisted of 5,107 NCE physics students. A multistage sampling procedure was adopted. Purposive sampling was used to select participating colleges based on availability of technological facilities, after which stratified simple random sampling (based on level) was used to select 350 students. Intact classes were assigned to experimental (technology-enhanced learning tools) and control (demonstration method) groups. The Physics Performance Test (PPT), comprising 25 multiple-choice items, and the Impact of

Technology on Physics Education (ITPE) questionnaire were developed by the researcher. Content validity was established through expert review, while reliability was determined using KR-20 for the PPT and Cronbach's alpha for the ITPE questionnaire. A pretest was administered to establish baseline equivalence. The experimental group received technology-enhanced instruction (multimedia and computer-based simulations)

for three weeks, while the control group was taught using the conventional demonstration method. A posttest was subsequently administered to measure academic performance. Data were analyzed using mean and standard deviation to answer research questions. Independent samples t-test and regression analysis were used to test the hypotheses at the 0.05 level of significance.

DATA AND DISCUSSION OF RESULTS.

Table 1: Mean achievement scores of students taught physics using technology enhanced learning tools compared to those taught without

Group	Pretest		Post-test		Mean Gain	
	N	\bar{x}	SD	\bar{x}		SD
Experimental	165	32.83	2.89	63.67	4.59	30.84
Control	185	33.64	4.02	46.09	5.33	12.45

Source: field survey, 2026.

Table 1 shows the mean achievement scores of students taught Physics using technology-enhanced learning tools and those taught using the traditional method. The experimental group had a pretest mean score of 32.83 (SD = 2.89) and a post-test mean score of 63.67 (SD = 4.59), resulting in a mean gain of 30.84. In contrast, the control group had a pretest mean of 33.64 (SD = 4.02) and a post-test mean of 46.09 (SD = 5.33), with a mean gain of 12.45.

Although both groups improved, the experimental group recorded a substantially higher mean gain. This indicates that technology-enhanced learning tools significantly improved students' academic achievement in Physics compared to the traditional teaching approach.

Table 2: T-test of academic achievement scores of students taught physics using technology enhanced learning tools compared to those taught without

Group	N	Df	\bar{x}	SD	t-value	p-value	Decision
Experimental	165	38	17.13	1.21	8.62	0.00	Sig
Control	185		13.95	1.16			

Significant at $p > 0.05$ level

Source: field survey, 2026.

Table 2 presents the t-test analysis comparing academic achievement between the experimental and control groups. The calculated t-value of 8.62 with a p-value of 0.00 indicates statistical significance at the 0.05 level. Since $p < 0.05$, the null hypothesis is rejected.

This means there is a statistically significant difference in the academic achievement of students taught Physics using technology-enhanced learning tools and those taught without such tools. Students exposed to technology performed significantly better.

Table 3: Mean engagement and motivation scores of students taught physics using technology enhanced learning tools compared to those taught without

Group	N	Engagement		Motivation		Mean Gain
		\bar{x}	SD	\bar{x}	SD	
Experimental	165	4.12	9.06	4.76	3.99	4.44
Control	185	3.01	4.34	3.09	6.26	3.05

Source: field survey, 2026.

Table 3 shows the mean engagement and motivation scores of students in both groups. The experimental group recorded higher engagement ($\bar{x} = 4.12$) and motivation ($\bar{x} = 4.76$) compared to the control group (engagement $\bar{x} = 3.01$; motivation $\bar{x} = 3.09$). The mean gain for the experimental group (4.44) was also higher than that of the control group (3.05).

This suggests that technology-enhanced instruction positively influenced students' engagement and motivation in Physics lessons.

Table 4: Model Summary

Model	R	R ²	F	Sig.
1	0.53	0.28	108.60	0.000

Source: field survey, 2026.

Table 4 (Model Summary) shows $R = 0.53$ and $R^2 = 0.28$, indicating that 28% of the variation in students' engagement and motivation is explained by the use of technology-enhanced learning tools. The F-value (108.60) with $p = 0.000$ confirms that the regression model is statistically significant.

Table 5: Regression Coefficients for engagement and motivation

Predictor	B	t-value	Sig.(P)
technology enhanced learning tools	0.53	10.42	0.000

Significant at $p > 0.05$ level

Source: field survey, 2026.

Table 5 shows that technology-enhanced learning tools significantly predict engagement and motivation ($\beta = 0.53$, $t = 10.42$, $p = 0.000$). This implies that increased use of technology positively influences students' engagement and motivation in Physics.

Table 6: Effective strategies for integrating technology into the teaching and learning of Physics

SN	ITEMS	Mean	Std. Deviation	Decision
1	Institutional support, funding, and technical assistance are essential for successful technology integration in Physics education.	4.43	.752	Accepted
2	The use of multimedia presentations and video demonstrations improves students' understanding of Physics concepts.	4.16	.995	Accepted
3	Proper lesson planning that incorporates technology improves teaching effectiveness in Physics.	4.46	.815	Accepted
4	Availability of adequate technological infrastructure (computers, projectors, internet) supports effective integration.	4.18	.955	Accepted
5	Teachers' confidence and positive attitude toward technology influence its successful classroom integration.	2.77	1.323	Rejected
6	Teachers require adequate ICT training to effectively integrate technology into Physics teaching.	3.73	1.171	Accepted
7	Student-centered approaches such as flipped classrooms and collaborative digital projects enhance learning outcomes in Physics.	3.78	1.007	Accepted
8	Virtual laboratories and online simulations make abstract Physics concepts easier to understand.	3.76	1.074	Accepted
9	Technology-based instructional strategies increase students' engagement during Physics lessons.	4.13	.873	Accepted
10	Digital tools such as online quizzes and assignments improve students' motivation to learn Physics.	3.87	1.101	Accepted
Grand mean		3.93	1.00	

Source: field survey, 2026.

Table 6 presents effective strategies for integrating technology into Physics teaching. With a grand mean of 3.93, respondents generally agreed that institutional support, multimedia use, lesson planning, infrastructure, ICT training, student-centered approaches, virtual laboratories, and digital tools enhance Physics teaching. However, teachers' confidence and positive attitude toward technology (mean = 2.77) was rejected, indicating a potential challenge in implementation.

Discussion of Findings

The findings of this study revealed that technology-enhanced learning significantly improved students' academic achievement in Physics. The experimental group recorded a substantially higher mean gain and the t-test result confirmed a statistically significant difference between the two groups. This finding is consistent with the Cognitive Theory of Multimedia Learning proposed by Richard Mayer (2001), which states that students learn more deeply from words and pictures

than from words alone. The use of simulations, animations, and virtual laboratories likely reduced cognitive overload and enhanced meaningful learning. Similarly, John Hattie (2009), in his meta-analysis of factors influencing student achievement, reported that technology integration, when effectively implemented, has a positive and significant effect on students' academic performance. The present study supports these earlier findings by demonstrating improved achievement in Physics through technology-enhanced instruction.

The study further revealed that technology-enhanced learning significantly increased students' engagement and motivation in Physics classes. The higher engagement and motivation mean scores recorded by the experimental group suggest that digital tools created a more interactive and stimulating learning environment. This aligns with the constructivist theory of Lev Vygotsky (1978), which emphasizes social interaction and active participation in knowledge construction. Technology-supported collaborative tasks and simulations likely facilitated such interactive learning. Additionally, Albert Bandura (1977) in his Social Learning Theory explained that learners acquire knowledge through observation, modeling, and interaction within their environment.

Digital platforms and multimedia tools provide such interactive opportunities, thereby enhancing motivation and engagement. The regression result showing that technology explained 28% of the variance in engagement and motivation further strengthens this theoretical alignment.

Moreover, the significant predictive influence of technology-enhanced learning tools on

engagement and motivation is consistent with the constructionist perspective of Seymour Papert (1980), who argued that learners are more motivated when they actively construct knowledge using technological tools. The findings of this study show that students exposed to virtual laboratories, simulations, and digital assessments demonstrated higher enthusiasm and participation. However, the rejection of teachers' confidence and positive attitude toward technology as a strong factor indicates implementation challenges. This observation supports earlier studies that emphasize the importance of teacher competence and professional development in successful technology integration.

Overall, the present findings corroborate established theoretical and empirical literature that technology-enhanced learning improves academic achievement, engagement, and motivation in science education.

Conclusion

The study concluded that technology-enhanced learning tools significantly improve students' academic achievement, engagement, and motivation in Physics Education in Nigerian Colleges of Education. Technology not only enhances conceptual understanding but also creates interactive and student-centered learning environments. However, effective implementation depends largely on institutional support, infrastructure availability, and adequate ICT training for teachers.

Recommendations

- i. Colleges of Education in Nigeria should integrate technology-enhanced learning tools such as virtual laboratories, simulations, and multimedia presentations into Physics instruction.

- ii. Government and institutional administrators should provide adequate funding, infrastructure, and technical support for technology integration.
- iii. Regular ICT training and professional development programmes should be organized for Physics lecturers to improve their competence and confidence.
- iv. Student-centered strategies such as flipped classrooms and collaborative digital projects should be encouraged and policies should be developed to ensure sustainable implementation of technology in Physics Education.

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QUESTIONNAIRE ON IMPACT OF TECHNOLOGY ON PHYSICS EDUCATION IN NORTH CENTRAL NIGERIAN COLLEGES OF EDUCATION

Effect of Technology Integration on Student Engagement and Motivation in Physics Classes

SN	ITEMS	SA	A	U	SD	D
1	I pay more attention in physics class when digital tools are used.					
2	Technology makes physics lessons more interesting.					
3	Technology encourages collaboration with classmates.					
4	Multimedia presentations improve my concentration in class.					
5	I am more willing to ask questions during technology-enhanced lessons.					
6	The use of technology increases my interest in physics as a subject.					
7	I feel less bored during technology-integrated lessons.					
8	Technology increases my confidence in solving physics problems.					
9	I enjoy physics lessons more when technology is used.					
10	Technology makes physics concepts easier to visualize.					
11	I prefer technology-supported lessons to traditional lecture methods.					
12	I spend more time studying physics when digital resources are available.					
13	I participate more actively during technology-supported lessons.					
14	Simulations and virtual labs help me understand difficult concepts.					
15	I feel motivated to study physics when technology is integrated into teaching.					

Effective strategies for integrating technology into the teaching and learning of Physics

SN	ITEMS	SA	A	U	SD	D
16	Institutional support, funding, and technical assistance are essential for successful technology integration in Physics education.					
17	The use of multimedia presentations and video demonstrations improves students' understanding of Physics concepts.					
18	Proper lesson planning that incorporates technology improves teaching effectiveness in Physics.					
19	Availability of adequate technological infrastructure (computers, projectors, internet) supports effective integration.					
20	Teachers' confidence and positive attitude toward technology influence its successful classroom integration.					
21	Teachers require adequate ICT training to effectively integrate technology into Physics teaching.					
22	Student-centered approaches such as flipped classrooms and collaborative digital projects enhance learning outcomes in Physics.					
23	Virtual laboratories and online simulations make abstract Physics concepts easier to understand.					
24	Technology-based instructional strategies increase students' engagement during Physics lessons.					
25	Digital tools such as online quizzes and assignments improve students' motivation to learn Physics.					