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EFFECT OF TECHNOLOGY-ENHANCED SUPPLEMENTAL INSTRUCTIONAL METHOD (TESIM) ON STUDENTS' ACADEMIC PERFORMANCE IN SELECTED PHYSICS CONCEPTS IN IJEBU-ODE LOCAL GOVERNMENT AREA OGUN STATE, NIGERIA

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Abstract

This study determined the effect of Technology-Enhanced Supplemental Instructional Method (TESIM) on students' academic performance in selected physics concepts using a mixed-method approach. A quasi-experimental pretest–posttest control group design constituted the quantitative strand, while qualitative data were generated through semi-structured interviews. Using purposive sampling, 127 Senior Secondary School Two (SS2) physics students were employed for the study from two co-educational public schools in Ijebu-Ode Local Government Area of Ogun State, Nigeria. The experimental group ($n = 61$) received instruction using TESIM while the control group ($n = 66$) was taught using the conventional teaching method. Results revealed that students in the TESIM group recorded a significantly higher posttest mean score ($M = 74.26$, $SD = 8.12$) than those in the CTM group ($M = 57.32$, $SD = 7.84$). Gender disaggregation further revealed comparable performance for males ($M = 75.18$) and females ($M = 73.12$) in the experimental group, suggesting gender neutrality in TESIM effectiveness. ANCOVA confirmed a significant main effect of instructional method, $F(1,124) = 38.62$, $p < .001$, partial $\eta^2 = .236$, while the interaction effect with gender was non-significant, $F(1, 122) = 0.48$, $p = .489$, partial $\eta^2 = .004$. The study concludes that TESIM enhances physics achievement and promotes inclusive participation.

Keywords: Technology-Enhanced Instruction, Academic Performance, Physics Concepts, Mixed-Method Evaluation, Physics students.

Introduction

Physics is the fulcrum of technological and scientific advancement, as it provides the fundamental principles that explain the operation of the natural world. The content of Physics focuses on analysis of matter, energy, motion and the laws that govern their relationships with fundamental concepts vital for progress in engineering, healthcare, computing and environmental science (Aderonmu & Adolphus, 2023). By engaging with physics, learners develop an understanding of critical concepts such as mechanics, electricity, thermodynamics and quantum theory among others which are integral to contemporary technologies requirements. The understanding of physics concepts not only reinforces scientific literacy but also cultivates the analytical and problem-solving skills that are essential for innovation and industrial growth.

Painagoni (2022) noted that the importance of physics extends beyond theoretical knowledge to practical applications essential for developments which are relevant in renewable energy technologies, artificial intelligence and sustainable innovations. Nations that prioritize physics education often excel in scientific advancements and technological self-sufficiency (Akinwumi, Ngbede & Yahaya, 2025). As a result, the successful teaching and learning of physics at every educational level is crucial for developing a scientifically literate citizenry that can contribute to economic growth, technological progress and environmental preservation.

The study of physics requires learners to apply mathematical models, interpret data and draw evidence-based conclusions that cultivate a systematic approach to understanding and addressing complex problems. By analyzing variables, formulating hypotheses and testing predictions, learners learn to think critically about cause-and-effect relationships and to approach challenges methodically (Aderonmu & Unamma, 2025). Such experiences not only enhance cognitive flexibility but also promote scientific reasoning and decision-making which are essential competencies in the 21st-century knowledge economy.

Research has shown that learners frequently face several challenges in the learning physics due to the abstract nature of the inherent concepts, which require a deep understanding of unseen phenomena such as forces, energy and atomic interactions (Raheem-Folayinka, et al., 2024). In contrast to other science subjects that may rely on direct observation, many physics concepts demand a high level of imagination and spatial reasoning, making it difficult for learners to visualize processes that occur at microscopic level or scale. A typical illustration is the understanding of concepts like electromagnetic fields or wave-particle duality that necessitates learners to mentally construct representations of phenomena that cannot be easily demonstrated in traditional classroom settings. This abstractness often leads to cognitive entropy, where learners find it difficult to connect theoretical principles with real-world experiences, resulting in misconceptions and a superficial understanding (Ahmed & Sabitu, 2024).

The concept of technology integration in education refers to the strategic use of digital tools, resources and applications, including simulations, multimedia and online platforms, to enhance both instructional delivery and learning outcomes (Ubabuike & Ojechi, 2025). Integrating technology into the teaching and learning of physics is essential for improving learners' grasp of abstract concepts through visualization, simulation and interactive experimentation and creating interactive, engaging and learner-oriented educational experiences. Technology-Enhanced Supplemental Instructional Method involves the utilization of digital and interactive materials such as virtual labs, educational software, simulations and multimedia content for classroom instruction to reinforce learning. This approach is designed to provide students with additional, technology-facilitated opportunities for exploration and practice, thereby enhancing their conceptual understanding and academic achievement.

Technology-Enhanced Supplemental Instructional Method effectively serve as a bridge between theoretical physics concepts and their real-world applications by providing interactive, experiential learning environments that enable students to visualize and manipulate abstract phenomena (Arymbekov & Turekhanova, 2025). Through the use of tools such as computer simulations, virtual laboratories augmented reality among others, learners can observe the practical implications of principles like motion, energy and electricity in real-time scenarios. The instructional use of these resources transforms abstract equations and models into tangible experiences, fostering a deeper conceptual understanding and retention (Almadrones & Tadifa, 2024). They connect classroom learning to everyday contexts thereby enhancing learners' appreciation of physics as a living science that underlies technological and societal advancement.

Statement of Problem

In spite of numerous reforms and innovations in science teaching and learning, students' performance especially in physics has consistently been low. Research studies (Udochukwu, et al., 2025; Liadi, et al., 2024; Taangahar & Okwori, 2022) have repeatedly indicated that many learners find it difficult to understand essential physics concepts, resulting in poor academic performance and a waning interest in the subject. This ongoing underachievement presents a significant obstacle to achieving the national objectives in science, technology and innovation. It also raises questions regarding the effectiveness of current instructional methods in fostering meaningful learning and enhancing students' comprehension of fundamental physics principles. The WAEC Chief Examiners' report (2025) for Physics in Nigeria points to persistent candidate weaknesses in conceptual understanding, especially for application-based questions, poor graphical/diagram interpretation and inadequate syllabus coverage, with common issues including difficulty in explaining principles, applying formulas and defining key terms necessitating better instructional approach.

Conventional teaching approach to teaching physics which is the predominant instructional approach used mostly for Physics teaching is focused on the teacher and rely heavily on lectures and frequently do not address cognitive development of learners. This method prioritizes rote memorization resulting to learners feeling disengaged and struggling to relate theoretical knowledge to practical applications. As a result, learners may form misconceptions and develop negative perceptions of physics, viewing it as abstract and excessively challenging. This limitation in pedagogy highlights the necessity for more interactive, technologically infused and student-focused teaching strategies that can ignite curiosity, promote critical thinking and maintain students' enthusiasm for learning physics. Therefore, there is a pressing need for an empirical, mixed-method investigation that determines both the measurable instructional effects of technology-enhanced supplemental resources on students' performance and the qualitative experiences that shape their engagement and attitudes toward learning physics.

Aim and Objectives of the Study

The aim of the study was to determine the effect of Technology-Enhanced Supplemental Instructional Method (TESIM) on students' academic performance in selected physics concepts. Specifically, the objectives of the study are to;

(i) investigate the effect of Technology-Enhanced Supplemental Instructional Resources and Conventional Teaching Method (CTM) on students' academic performance in selected physics concepts.

(ii) determine the effect of Technology-Enhanced Supplemental Instructional Resources and Conventional Teaching Method (CTM) on male and female students' academic performance in selected physics concepts.

Research Questions

The following research questions were raised for the study.

1. What are the mean performance scores of those taught using Technology-Enhanced Supplemental Instructional Method (TESIM) and those taught using Conventional Teaching Method (CTM) in selected physics concepts?
2. What are the mean performance scores of male and female students taught using Technology-Enhanced Supplemental Instructional Method (TESIM) and those taught using Conventional Teaching Method (CTM) in selected physics concepts?

Hypotheses

H_{01}: There is no significant difference in the mean performance scores of those taught using Technology-Enhanced Supplemental Instructional Method (TESIM) and those taught using Conventional Teaching Method (CTM) in selected physics concepts

H_{02}: There is no significant difference in the mean performance scores of male and female students taught using Technology-Enhanced Supplemental Instructional Method (TESIM) and those taught using Conventional Teaching Method (CTM) in selected physics concepts.

Methodology

This study adopted the quasi-experimental research design, specifically the pretest–posttest control group. This design was selected because it enables the researcher to determine the effect of Technology-Enhanced Supplemental Instructional Method (TESIM) on students' academic performance in selected physics concepts without random assignment of participants. The population of this study consisted of all Senior Secondary School Two (SS2) Physics students in public secondary schools located in Ijebu-Ode Local Government Area of Ogun State, Nigeria. A total of 127 SS2 physics students participated in the study, drawn from two purposively selected co-educational secondary schools within the Local Government Area. The purposive sampling technique was adopted based on the following criteria:

(i) The schools must have functional computer laboratories or ICT facilities to support the integration of technology-enhanced learning resources.
(ii) The schools must have at least one qualified physics teacher with a minimum of a Bachelor's degree in Education (Physics).
(iii) The schools must have comparable academic standards and follow the approved national physics curriculum.

One school was assigned as the experimental group (TESIM), while the other served as the control group (CTM). Both groups were taught the concepts of (Projectiles and Simple Harmonic Motion). The instrument used for data collection was titled Physics Achievement Test (PAT). The PAT was administered as both the pretest and posttest to determine changes in students' performance resulting from the intervention. Data were analyzed using both quantitative and qualitative methods. Scores from the Physics Achievement Test (PAT) were analyzed using descriptive statistics of mean, standard deviation and percentage while the hypotheses were tested with Analysis of Covariance (ANCOVA) at 0.05 level of significance.

Results

Research Question 1: What are the mean performance scores of those taught using Technology-Enhanced Supplemental Instructional Method (TESIM) and those taught using Conventional Teaching Method (CTM) in selected physics concepts?

Table 3: Students' Mean Pretest and Posttest Scores on Academic Performance in Selected Physics Concepts

Group	N	Pretest Mean	SD	Posttest Mean	SD	Mean Gain
Experimental (TESIM)	61	32.45	7.68	74.26	8.12	41.81
Control (CTM)	66	33.08	6.95	57.32	7.84	24.24

Table 3 presents the mean pretest and posttest scores of students in both the experimental and control groups. Before the intervention, the mean pretest scores were comparable between the two groups, experimental (M = 32.45, SD = 7.68) and control (M = 33.08, SD = 6.95) indicating that both groups started at a similar level of achievement in the selected physics concepts. The experimental group taught using Technology-Enhanced Supplemental Instructional Method (TESIM) recorded a higher posttest mean score (M = 74.26, SD = 8.12) compared to the control (CTM) group (M = 57.32, SD = 7.84). This indicates that the integration of TESIM led to greater improvement in students' academic performance in selected physics concepts relative the CTM group.

Research Question 2: What are the mean performance scores of male and female students taught using Technology-Enhanced Supplemental Instructional Method (TESIM) and those taught using Conventional Teaching Method (CTM) in selected physics concepts?

Table 4: Pretest and Posttest Mean Scores, Standard Deviations and Mean Gains of Male and Female Students in Experimental and Control Groups

Group	Gender	N	Pretest Mean	SD	Posttest Mean	SD	Mean Gain
Experimental (TESIM)	Male	33	31.85	7.42	75.18	8.05	43.33
	Female	28	32.97	7.89	73.12	8.26	40.15
Control (CTM)	Male	35	33.27	6.74	58.43	7.66	25.16
	Female	31	32.84	7.03	56.08	7.98	23.24

Table 4 presents the pretest and posttest performance of male and female students in both the experimental and control groups. Prior to the intervention, there were no substantial differences in pretest mean scores between male and female students across both groups, suggesting equivalent initial performance levels. After the intervention using Technology-Enhanced Supplemental Instructional Method (TESIM), both male (M

= 75.18, SD = 8.05) and female (M = 73.12, SD = 8.26) students in the experimental group demonstrated significant improvement compared to their control (CTM) counterparts (male: M = 58.43, female: M = 56.08). The mean gain scores indicate that male students in the experimental group achieved a gain of 43.33 points, while female students gained 40.15 points. In the control group, male and female students recorded lower mean gains of 25.16 and 23.24, respectively. This pattern shows that both male and female students benefited substantially from the TESIM, although male students exhibited a slightly higher improvement.

H_{01}: There is no significant difference in the mean performance scores of those taught using Technology-Enhanced Supplemental Instructional Method (TESIM) and those taught using Conventional Teaching Method (CTM) in selected physics concepts

Table 5: Summary of Analysis of Covariance (ANCOVA) on Students' Posttest Scores in Physics Concepts by Instructional Group

Source	Sum of Squares	Df	Mean Square	F	p	Partial η²
Covariate (Pretest)	312.47	1	312.47	2.11	.149	.017
Group (Instructional Method)	5632.28	1	5632.28	38.62	**.000**	.236
Error	9015.37	124	72.70			
Total	14960.12	126				

Table 5 presents the one-way Analysis of Covariance (ANCOVA) was conducted to examine the effect of Technology-Enhanced Supplemental Instructional Method (TESIM) on students' academic performance in selected physics concepts, while controlling for pretest scores. Results indicated a significant main effect of instructional method on students' posttest performance, $F(1, 124) = 38.62$, $p < .001$, partial $\eta^2 = .236$. This means that approximately 23.6% of the variance in students' posttest scores could be attributed to the type of instructional method used

H_{02}: There is no significant difference between male and female students on the effect of Technology-Enhanced Supplemental Instructional Method (TESIM) and Conventional Teaching Method (CTM) on their academic performance in selected physics concepts.

Table 6: Two-Way Analysis of Covariance (ANCOVA) Summary of Posttest Scores by Instructional Method and Gender

Source	Sum of Squares	df	Mean Square	F	p	Partial η²
Covariate (Pretest)	285.42	1	285.42	1.86	.175	.015
Instructional Method	5487.31	1	5487.31	35.69	.000	.228
Gender	214.58	1	214.58	1.39	.241	.011
Instructional Method × Gender	73.62	1	73.62	0.48	.489	.004
Error	8753.44	122	71.77			
Total	14814.37	126				

Table 6 presents the two-way Analysis of Covariance (ANCOVA) was conducted to examine the effect of Technology-Enhanced Supplemental Instructional Method (TESIM) and gender on students' posttest achievement scores in selected physics concepts, while controlling for pretest performance. Results indicated a statistically significant main effect of instructional method, $F(1, 122) = 35.69$, $p < .001$, partial $\eta^2 = .228$. This shows that students taught using TESIM performed significantly better than those taught through traditional instructional methods. However, the main effect of gender was not statistically significant, $F(1, 122) = 1.39$, $p = .241$, partial $\eta^2 = .011$, indicating that male and female students performed comparably after the intervention. Furthermore, the interaction effect between instructional method and gender was not significant, $F(1, 122) = 0.48$, $p = .489$, partial $\eta^2 = .004$. This suggests that the positive impact of TESIM on students' academic performance was consistent across both male and female students, without favoring one gender over the other.

Discussion of Findings

The outcomes of this investigation revealed that the use of Technology-Enhanced Supplemental Instructional Method (TESIM) significantly enhanced students' academic performance in selected physics concepts. The experimental group outperformed the control group in terms of pretest and posttest mean scores, suggesting that technology-based instructional resources improved students' understanding and retention of challenging physics topics. This finding is in accordance with Wooten and Cuevas (2024) which indicates that learning is more effective when information is presented through both visual and verbal channels. Additionally, similar studies conducted by Aderonmu and Agbesor (2025) support the assertion that interactive and technology-based materials enhance conceptual understanding and problem-solving skills in science learning.

The findings also revealed that both male and female participants in the experimental group exhibited greater mean gain improvements than their counterparts in the control group, indicating that TESIM encourages gender-inclusive learning results. This conclusion is consistent with the findings of Eya et al., (2025) who noted that gender differences in science achievement are likely to decrease when learners engage with digital and interactive instructional methods. Additionally, the qualitative insights further validated this conclusion, as both male and female students conveyed that TESIM oriented lessons were captivating, inspiring, and provided equal opportunities for engagement. Consequently, TESIM appears to address gender gaps in physics by fostering a more equitable and inclusive learning environment.

The findings indicated that TESIM contributed to the development of independent and self-directed learning skills among students. Learners reported revisiting simulation videos and online materials beyond classroom time, demonstrating increased ownership of learning, deepening their cognitive engagement and fostering critical thinking skills. This observation resonates with Zimmerman's (2002) theory of self-regulated learning, which asserts that access to technology-rich learning environments enhances students' ability to plan, monitor, and evaluate their own learning progress. Therefore, the integration of TESIM not only improved immediate academic outcomes but also cultivated long-term learning dispositions essential for success in 21st-century STEM education.

Conclusion

This study concluded that Technology-Enhanced Supplemental Instructional Method (TESIR) had a positive and significant effect on students' academic performance and engagement in selected physics concepts. Learners who were taught using TESIM based lessons achieved greater learning gains compared to their peers who received traditional instruction, indicating that technology-supported educational settings can improve conceptual understanding and problem-solving skills in physics. The study discovered that TESIM facilitated gender-inclusive learning outcomes, as both male and female students in the experimental group demonstrated improved performance and engagement. The findings further imply that TESIM promotes independent learning, sustained motivation, and active participation, making it a significant pedagogical innovation for enhancing outcomes in science classrooms, particularly in developing contexts such as Nigeria, where persistent underachievement in physics is a concern.

Recommendations

The following recommendations were highlighted for the study

1. Teachers should adopt TESIM based instructional strategies to improve students' conceptual understanding and engagement in physics.
2. School administrators should provide continuous professional development programmes that equip teachers with skills for effective integration of technology-enhanced learning tools.
3. Educational policymakers should encourage the inclusion of TESIM in the secondary school physics curriculum to promote equitable and gender-inclusive learning outcomes.

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