

Harnessing Educational Technology for Effective Science Pedagogy in Tertiary Institutions Amidst Economic Challenges in Anambra State

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Abstract

Amidst ongoing economic hardship, science education in tertiary institutions faces the challenge of maintaining relevance while ensuring quality learning outcomes that foster innovation and national development. This study examined the influence of harnessing educational technology for effective science pedagogy in tertiary institutions in Anambra State. Guided by three research questions and two null hypotheses tested at a 0.05 significance level, the study employed a descriptive survey design. The population comprised 128 science education lecturers (52 males and 76 females) in public universities across the state, with a census approach adopted for data collection. A 22-item expert-validated questionnaire developed by the researchers served as the data collection instrument, achieving a reliability coefficient of 0.87 using Cronbach's Alpha. Data were analysed using mean and standard deviation, while t-test was used to test the hypotheses with SPSS version 25. Findings revealed a moderate level of awareness and utilisation of technology-enhanced instructional tools among science education lecturers. Results further indicated no significant gender difference in awareness levels. Major challenges identified included limited access to digital tools, poor electricity and internet connectivity, and inadequate institutional support. The study concluded that, despite moderate awareness, the full potential of educational technology in science pedagogy remains underutilised. It recommended continuous capacity building, improved infrastructural support, and strategic investment in digital tools to foster an inclusive, technology-driven learning environment in tertiary institutions of Anambra State.

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1. Introduction

Science education is very important for laying the foundation for progress in technology, economy and society as a whole. In addition to equipping individuals with relevant skills, inclusive science education plays a crucial role in unlocking a nation's economic potential. For developing countries such as Nigeria, science education forms a foundational pillar in promoting self-sufficiency and reducing overreliance on foreign expertise and imported solutions. While science education focuses on the broad goals of fostering scientific literacy and preparing learners for real-world problem-solving, science pedagogy provides the practical framework and instructional strategies through which these educational objectives are effectively achieved in the classroom.

Pedagogy refers to the art, science and profession of teaching. Pedagogy, being the art of teaching, involves conveyance of knowledge and skills in ways that students can understand, remember and apply (Kaluyu & Ndiku, 2020). It also entails interactions between teachers, students, the learning environment and the learning tasks. Science pedagogy therefore refers to the study of diverse teaching methods and the processes through which humans acquire and apply knowledge. Contemporary frameworks emphasize balanced, comprehensive inquiry rather than purely investigative activities. For instance, Schwartz, Duncan and Gallagher (2023) propose a Comprehensive Inquiry-Based Science Education (CIBSE) model that integrates short exploratory tasks with scaffolded support for reasoning, explanation and argumentation, aligning closely with the engineering practices. Malone and Schuchardt (2023) demonstrate that early and sustained exposure to scientific modelling significantly enhances students' scientific reasoning and content understanding, particularly benefiting those who begin at lower proficiency levels.

Effective implementation of these pedagogical innovations depends on targeted teacher support and reflective practice. Aidoo's (2023) reflective study on inquiry-based teaching highlights the necessity of professional learning that moves beyond one-off workshops to sustained, community-based development, enabling educators to balance autonomy and guidance within inquiry activities. Moreover, Markula & Aksela (2022) highlight the role of technological scaffolds and collaborative structures such as peer discussion, digital simulations and structured questioning in promoting student agency and creativity within inquiry-based environments. As such, contemporary science pedagogy not only prescribes research-driven frameworks but also calls for systemic investments in teacher capacity building to realize equitable, high-quality science learning for all students. In an era defined by rapid technological advancement, the integration of digital tools into teaching and learning processes has become not only desirable but essential. By integrating educational technology such as interactive simulations, digital labs, and data-analysis tools, science pedagogy can move beyond traditional hands-on methods to create more personalized, inquiry-driven learning experiences that deepen students' understanding and engagement.

Educational technology refers to the use of technological tools, processes and resources in the teaching and learning process, aimed at enhancing student learning outcomes and overall academic performance. Huang, Spector and Yang (2019) describe educational technology as the collection of tools, resources and technological innovations that enhance the quality of learning. This encompasses both hardware such as tablets, computers and webcams and software solutions, including learning management systems, simulations and emerging technologies like augmented and virtual reality platforms. Undoubtedly, technology has greatly enhanced modern education; however, many students particularly in Nigeria still face unequal access to these technological advancements due to various challenges (Hussain, Qureshi & Malik, 2024; Adeoye, Mahmood, & Ali, 2020). The integration of educational technology into science teaching has been widely recognized for its potential to improve instructional quality and student learning outcomes. Winter et al. (2021) reported that the use of technology offers deeper understanding of certain educational processes and introduces innovative tools that enhance both teaching and learning activities. The awareness on integration of educational technology is a must for all science lecturers.

Onwuagboke *et al.* (2024) observed that lecturers are aware of AI tools for teaching and research. Also, Fakomogbon, Olanrewaju and Soetan (2015) observed that in state-owned colleges of education in South-West Nigeria, lecturers demonstrated limited utilization of instructional media, even though awareness levels were adequate, suggesting that capacity building remains a critical gap in actual technology integration. Ubogu (2013) reported that lecturers only use ICT in lecturing to a low extent and do not use it for teaching/learning because of different factors affecting ICT. Furthermore, Firmansyah (2025) reported that the use of technology-enhanced tools such as animations, simulations, and interactive applications increases students' intrinsic motivation by making learning more enjoyable and relevant to real-world contexts. Muhammad and Schneider (2021) emphasized the role of EdTech platforms in fostering learner autonomy and sustained interest in academic tasks. In a related study, Lee, Shih, Liang, and Tseng (2021) showed that participatory simulations in science education not only promoted active learning but also led to better conceptual understanding and improved student performance.

However, despite the promise of educational technology, several challenges continue to hinder its full-scale implementation in Nigerian tertiary institutions. Ademola-Popoola and Adesina (2025) revealed that inadequate broadband infrastructure and poor ICT network services restrict seamless access to digital platforms in many universities. This is also echoed by Eze, Chinedu-Eze and Bello (2018), who reported low utilisation of e-learning facilities in Nigerian universities due to limited funding, insufficient training, and lack of institutional commitment to ICT development. Similarly, Awodoyin and Fajiwe (2024) stated that poor internet connectivity, epileptic power supply, inadequate slow bandwidth were the main challenges encountered by the science lecturers while using the remote platforms. Likewise, Winter et al., (2021) reported the first-order barriers are actually non-teacher factors such as availability of equipment, access to resources, training and support. Also, (de Guzman, 2022) highlighted one of the biggest obstacles to technology integration as the problem of access to the internet. Adov and Mäeots (2021) stated that schools and local governments should support the necessary technology access to solve the problem of poor infrastructure or internet in the context of their research. Nevertheless, within the context of Nigerian tertiary institutions specifically, in Anambra State, a considerable gap persists in both the practical implementation and institutional readiness for technological learning. In contrast, while educational technology holds great potential to revolutionize science pedagogy, its impact can only be fully understood by examining the current state of science teaching in tertiary institutions across Anambra State, where challenges of infrastructure, funding and access continue to shape instructional realities. The current landscape of science teaching in tertiary institutions in Anambra State reflects both progress and persistent challenges. Oliobi, Nwankwo, Uzor & Okoli (2022) averred that infrastructural deficits such as under-equipped laboratories, intermittent power supply and limited access to digital resources continue to constrain the hands-on, inquiry-based approaches that are essential to effective science learning. Though awareness rates exceeded 70%, technical proficiency, institutional support and perceived relevance to course outcomes were cited as barriers by nearly half of respondents.

Notwithstanding, the growing need for the integration of educational technology such as virtual laboratories, interactive simulations, and e-learning platforms to align with global standards and improve students' scientific competencies, institutions in Anambra State face systemic underfunding and infrastructural deficits (BudgIT, 2024; Ndukwe & Okonkwo, 2022). This presents a critical paradox: while the demand for technologically enriched science instruction continues to grow, especially in the wake of digital transformation imperatives, the financial realities confronting these institutions constrain their ability to innovate and modernize. Without targeted interventions and sustained investments, the goal of transforming science pedagogy through educational technology in Anambra State may remain largely unfulfilled. The high cost of technological tools, inadequate infrastructure and limited budgetary allocations have significantly hindered the ability of universities and colleges in the state to adopt and sustain modern teaching methods. While educational technology such as virtual laboratories, interactive simulations and e-learning platforms holds immense potential to enhance science teaching and learning outcomes, the reality in Anambra State is that many institutions lack the financial and technical capacity to implement these innovations. This has led to a persistent gap between the intended goals of science education reform and the actual classroom experience. Consequently, there is a pressing need to investigate how educational technology can be harnessed for effective science pedagogy in tertiary institutions amidst economic challenges across the State.

1.1. Purpose of the study

The purpose of the study was to investigate the influence of harnessing technology for effective science pedagogy in tertiary institutions amidst economic crises in Anambra State. Specifically, the study sought to investigate:

- a. The level of awareness of educational technology among science education lecturers in public universities in Anambra State.
- b. The extent of utilisation of educational technology among science education lecturers in public universities in Anambra State.
- c. To identify the major challenges of educational technology integration faced by science education lecturers in public universities in Anambra State.

1.2. Research Questions

The following research questions guided the study

- a. What is the level of awareness of technology-enhanced instructional tools among science education lecturers in public universities in Anambra State?
- b. What is the level of utilisation of technology-enhanced instructional tools among science education lecturers in public universities in Anambra State?
- c. What are the major challenges faced by science education lecturers in public universities in Anambra State?

1.3. Hypotheses

The following hypotheses were tested at 0.05 level of significance

- a. Male and female science education lecturers do not significantly differ in their awareness of technology-enhanced instructional tools in public universities in Anambra State.
- b. Male and female science education lecturers do not significantly differ in their utilisation of technology-enhanced instructional tools in public universities in Anambra State.

2. Method

A descriptive survey research design was adopted for the study. The study was conducted in public universities in Anambra State of Nigeria. The population of the study comprised 128 (56 males and 72 females) science education lecturers obtained from public universities in Anambra State. The entire population was used for the study, this is because the population was small and manageable. Instrument used for data collection was a 22-item questionnaire developed by the researchers, the instrument titled "Educational Technology Integration Scale (ETIS)". The questionnaire is divided into three clusters with four point ratings. ETIS consist of four sections; Section A elicits information from the personal data of the respondent, section B contains eight items relating to awareness level of science education lecturers on education technology enhanced tools, section C contains eight items relating to level of utilisation of education technology tools among science education lecturers, and section D contains six items on challenges faced by science education lecturers on integration of

education technology tools, with ratings ranging from 1=Strongly Disagree (SD), 2=Disagree (D), 3=Agree (A) to 4=Strongly Agree (SA). The ETIS was subjected to face and content validation by three experts, two from Faculty of Education, Nnamdi Azikiwe University, Awka. The overall reliability coefficient of the instrument was established at 0.87 using Cronbach's Alpha method. 128 copies of the questionnaire were administered to the respondents by the researchers together with two research assistants. Out of 128 copies administered 124 were validly completed and returned, representing a 97% response rate. The data collected was analysed using mean, standard deviation and t-test with SPSS vs.25. Mean and standard deviation were used to answer the research questions while t-test was used to test the hypotheses. In this study, the level of acceptance or rejection of each questionnaire items were determined based on the mean ratings of items interpreted relative to real limits of numbers as shown in Table 1.

Table 1. Response Rating Scale

Response Category Rating	Number Limits
High Level	3.50 – 4.00
Moderate Level	2.50 – 3.49
Low Level	1.50 – 2.49
Very Low Level	1.00 – 1.49

For hypothesis testing using t-test, a 0.05 level of significance was adopted, where a p -value ≤ 0.05 , the null hypothesis was rejected, indicating a significant difference between the groups, otherwise, was retained.

3. Results and Discussion

3.1. Results

3.1.1. Research Question 1: What Is the Level of Awareness of Technology-Enhanced Tools Among Science Education Lecturers in Public Universities in Anambra State?

Table 2 shows the mean and standard deviation on the level of awareness of technology-enhanced instructional tools among science education lecturers in public universities in Anambra State. The respondents rated items 1, 4 and 5 as high, while items 2, 3, 6, 7 and 8 were rated moderate. On the whole, the cluster mean score of 3.42 reveals that the respondents rated the level of awareness of technology-enhanced instructional tools among science education lecturers as moderate. The standard deviation scores show homogeneity in the respondents rating (0.49-0.72).

Table 2. Mean Ratings On the Level of Awareness of Technology-Enhanced Tools Among Science Education Lecturers in Public Universities in Anambra State

Item No.	Statement	Mean ($\bar{x}$)	SD	Decision
1	I am aware that Learning Management Systems (e.g., Moodle, Google Classroom) enhance science lesson delivery.	3.62	0.55	High
2	I am aware that virtual laboratory platforms support hands-on learning of science concepts.	3.41	0.63	Moderate
3	I am aware that interactive whiteboards can be used to demonstrate scientific processes.	3.36	0.67	Moderate
4	I am aware that mobile apps support student engagement and conceptual understanding in science.	3.52	0.59	High
5	I am aware that video conferencing tools enhance collaboration in science instruction.	3.68	0.49	High
6	I am aware that digital assessment tools help monitor students' understanding in science lessons.	3.44	0.64	Moderate
7	I am aware that virtual and augmented reality tools improve students' grasp of abstract science concepts.	3.38	0.61	Moderate
8	I am aware that open educational resources provide access to updated science teaching content.	2.97	0.72	Moderate
Cluster Mean		3.42	0.61	Moderate

3.1.2. Research Question 2: What Is the Level of Utilization of Technology-Enhanced Instructional Tools by Science Education Lecturers in Public Universities in Anambra State?

Table 3 reveals the mean and standard deviation on the level of utilisation of technology-enhanced instructional tools among science education lecturers in public universities in Anambra State. The respondents rated items 9, 11, 14 and 15 as moderate, while items 10, 12, 13 and 15 as moderate. On the whole, the cluster mean score of 2.77 reveals that the respondents rated the level of utilisation of technology-enhanced instructional tools as moderate. The standard deviation scores show homogeneity in the respondents rating (0.35-0.65).

Table 3. Mean and Standard Deviation Ratings on the Level of Utilisation of Technology-Enhanced Instructional Tools Among Science Education Lecturers in Public Universities in Anambra State (n = 124).

Item No.	Statement	Mean ($\bar{x}$)	SD	Decision
9	I use Learning Management Systems to share resources and manage science instruction.	2.51	0.48	Moderate
10	I use virtual laboratories or simulations to teach science experiments.	2.41	0.40	Low
11	I use interactive whiteboards to illustrate science diagrams and concepts.	3.22	0.65	Moderate
12	I use educational science apps to improve student learning.	2.36	0.41	Low
13	I use video conferencing tools to teach science lessons remotely.	2.48	0.35	Low
14	I use digital assessment tools to evaluate student understanding during science classes.	3.30	0.60	Moderate
15	I use augmented or virtual reality tools to support science teaching.	2.45	0.53	Low
16	I use open educational resources to enrich my science teaching content.	3.42	0.59	Moderate
Cluster Mean		2.77	0.50	Moderate

3.1.3. Research Question 3: What Are the Major Challenges Faced by Science Education Lecturers in Public Universities in Anambra State?

Table 4 shows the mean and standard deviation on the major challenges faced by science education lecturers in public universities in Anambra State. The respondents rated items 17 and 18 as high, item 20 as moderate, and while items 19, 21 and 22 as low. On the whole, the cluster mean of 2.97 reveals that the respondents rated the major challenges faced by science education lecturers in public universities in Anambra State as moderate. The standard deviation scores show homogeneity in the respondents rating (0.42-0.69). This indicates that the major challenges faced by science education lecturers in public universities in Anambra State include lack of access to digital tools, poor electricity and internet connectivity, and insufficient institutional support, as reflected by the high and moderate mean ratings on these items.

Table 4. Mean Ratings on the Major Challenges of Technological Integration Faced by Science Education Lecturers in Tertiary Institutions in Anambra State

Item No.	Statement	Mean ($\bar{x}$)	SD	Decision
17	Lack of access to digital tools hinders my integration of technology in science teaching.	3.58	0.61	High
18	Poor electricity and internet connection affect my use of technology in science classes.	3.76	0.50	High
19	I lack sufficient training or digital competence to effectively use advanced educational technologies in science instruction.	2.34	0.43	Low
20	Lack of institutional support or encouragement discourages my efforts to adopt educational technology tools.	3.44	0.69	Moderate
21	Time constraints make it difficult to integrate technology into my science lessons.	2.29	0.48	Low
22	There is limited availability of subject-specific digital content for science instruction.	2.36	0.42	Low
Cluster Mean		2.96	0.52	Moderate

3.1.4. Hypothesis 1: Male and Female Science Education Lecturers Do Not Significantly Differ in Their Awareness of Technology-Enhanced Instructional Tools in Public Universities in Anambra State.

Result presented in Table 5 shows the t-test summary of the mean ratings of male and female science education lecturers' awareness of technology-enhanced instructional tools in public universities in Anambra State. From the analysis, the p -value is greater than the significant level ($0.77 > 0.05$), hence the null hypotheses is not rejected. This implies that male and female science education lecturers do not significantly differ in their awareness of technology-enhanced instructional tools in public universities in Anambra State.

Table 5. t-Test Summary on the Mean Ratings of Male and Female Science Education Lecturers' Awareness of Technology-Enhanced Instructional Tools in Public Universities in Anambra State (n = 124)

Sources of variance	N	Mean	SD	Df	t-cal	p-value	Decision
Male Lecturers	53	3.39	0.59	122	0.27	0.77	Not Sig.
Female Lecturers	71	3.44	0.62				

3.1.5. Hypothesis 2: Male and Female Science Education Lecturers Do Not Significantly Differ in Their Utilisation of Technology-Enhanced Instructional Tools in Public Universities in Anambra State

Result presented in Table 6 shows the t-test summary of the mean ratings of male and female science education lecturers' utilisation of technology-enhanced instructional tools in public universities in Anambra State. From the analysis, the p -value is greater than the significant level ($0.64 > 0.05$), hence the null hypotheses is not rejected. Thus, male and female science education lecturers do not significantly differ in their utilisation of technology-enhanced instructional tools in public universities in Anambra State.

Table 6. t-Test Summary on the Mean Ratings of Male and Female Science Education Lecturers' Utilisation of Technology-Enhanced Instructional Tools in Public Universities in Anambra State (n = 124)

Sources of variance	N	Mean	SD	Df	t-cal	p-value	Decision
Male Lecturers	53	2.75	0.49	122	0.44	0.64	Not Sig.
Female Lecturers	71	2.79	0.51				

3.2. Discussion

The findings of this study revealed that there is a moderate level of awareness of technology-enhanced instructional tools among science education lecturers in public universities in Anambra State. This indicates that science lecturers in public universities in Anambra State are moderately aware of technology-enhanced tools used for effective science teaching. The finding of this study aligns with that of Chinedu, Eze and Bello (2018), whose study indicated that ICT integration improves lecturers' pedagogical practices and that awareness levels are moderately high across institutions. Similarly, Abubakar *et al.* (2025) reported that while science lecturers are fully aware of virtual learning resources, their utilization of these resources remains limited. Also, Onwuagboke *et al.* (2024) stated that lecturers are aware of AI tools for teaching and research. Contrarily, the finding of Fakomogbon, Olanrewaju, and Soetan (2023) showed that some tertiary institutions in northern Nigeria still lag behind in awareness and use of ICT tools for science pedagogy.

The findings of this study also revealed that there is a moderate level of utilisation of technology-enhanced instructional tools among science education lecturers in public universities in Anambra State. This implies that science education lecturers in public universities moderately utilize technology-enhanced instructional tools for science teaching. The findings of this study agrees to that of Fakomogbon, Olanrewaju and Soetan (2015) who observed that in state-owned colleges of education in South-West Nigeria, lecturers demonstrated limited utilization of instructional media, even though awareness levels were adequate, suggesting that capacity building remains a critical gap in actual technology integration. Likewise, the study of Lee (2021) showed that lecturers who frequently used educational technology demonstrated more student-centered and effective pedagogical approaches. On the other hand, Adeoye, Mahmood, and Ali (2020) found that although lecturers had high awareness, only a small proportion used technology tools frequently in their classroom practice due to institutional challenges.

The findings of this study also revealed that the major challenges faced by science education lecturers in public universities in Anambra State as moderate. The major challenges faced by science education lecturers

include: lack of access to digital tools, poor electricity and internet connectivity and insufficient institutional support. These findings resonate with that of Winter et al., (2021) who found that First-order barriers are actually non-teacher factors such as availability of equipment, access to resources, training, and support. Correspondingly, Adeoye et al. (2022) also revealed that unstable power supply, limited internet access and insufficient funding remain major obstacles in Nigerian higher education institutions. Similarly, de Guzman (2022) reported that one of the biggest obstacles to technology integration is the problem of access to the internet. Furthermore, Oliobi, Nwankwo, Uzor & Okoli (2022) averred that infrastructural deficits such as under-equipped laboratories, intermittent power supply and limited access to digital resources continue to constrain the hands-on, inquiry-based approaches that are essential to effective science learning. In addition, Ademola-Popoola and Adesina (2025) revealed that inadequate broadband infrastructure and poor ICT network services restrict seamless access to digital platforms in many universities.

The findings on hypothesis one showed that male and female science education lecturers do not significantly differ in their awareness of technology-enhanced instructional tools in public universities in Anambra State. This finding aligns with that of Onwuagboke *et al.* (2024) who found that there was no significant difference in awareness according to gender. Contrarily, Ubogu, R. E. (2013) showed that there was a significant difference between awareness of male and female lecturers in Tertiary Institutions in Nigeria.

Hypothesis two revealed that male and female science education lecturers do not significantly differ in their utilisation of technology-enhanced instructional tools in public universities in Anambra State. This finding disagrees to that Onasanya et al. (2011) who found that there was significant difference between the mean scores for male and female science teachers in their level. Also, Ubogu, R. E. (2013) showed that there was a significant difference between utilisation of male and female lecturers in Tertiary Institutions in Nigeria. The present study suggests that male and female science education lecturers in public universities in Anambra State utilise technology-enhanced instructional tools at a similar level.

3.3. Recommendations

- a. Government and educational authorities in Anambra State should prioritize the provision of reliable electricity, high-speed internet and modern ICT facilities in tertiary institutions. This will reduce the infrastructural challenges that hinder the effective integration of educational technology in science pedagogy.
- b. Regular training workshops and digital skill enhancement programs should be organized for science lecturers to improve their competence in using educational technology tools effectively. This will bridge the digital skill gap and encourage innovative, student-centered teaching approaches.
- c. Stakeholders in the education sector, including management boards and policy makers, should allocate dedicated funding for the acquisition, maintenance, and upgrading of educational technologies. Clear policies should also be developed to support and monitor the consistent integration of digital tools in science teaching across tertiary institutions.
- d. Policy reforms, capacity building and investment in educational technologies should be provided to create a sustainable and inclusive digital learning environment.

4. Conclusion

Based on the findings, the study concludes that science education lecturers in public universities in Anambra State demonstrate a moderate level of awareness and utilisation of technology-enhanced instructional tools for effective science teaching. Although, lecturers are generally familiar with digital and virtual learning resources, their actual usage remains modest, often hindered by infrastructural and institutional challenges such as limited access to digital tools, inadequate power supply, poor internet connectivity and inadequate support systems. These findings highlight the need for sustained investment in infrastructure and capacity building to bridge the gap between awareness and effective integration of technology in science education. Furthermore, the study found no significant gender difference in both awareness and utilisation levels, indicating a uniform adoption pattern among male and female lecturers in the region.

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