Pedagogical Shifts in Science Teaching: Exploring Technology-Driven Instructional Materials in Taraba State, Nigeria

Sabo Umar

Registry Department, College of Education, Zing | Saboumarlokaci@gmail.com | 07038004690

Abubakar Fati Bassi

fatiabubakar4real@gmail.com | 08039706644 | Department of Integrated Science, College of Education, Zing

Abubakar, Karima Bassi

karimaabubakarbassi@gmail.com | 07031858648 | Department of Chemistry, College of Education, Zing | &

Samuel Shininba Alhamdu

samuelshinigaba@gmail.com | 09139368828 | Department of Chemistry, College of Education, Zing

DOI : https://doi.org/10.5281/zenodo.17247321

Abstract

This study investigates the pedagogical shifts in science teaching within Taraba State, Nigeria, with a focus on the integration of technology-driven instructional materials. Despite global advancements in digital education, many secondary schools in the region face persistent gaps in infrastructure, teacher preparedness, and curriculum alignment. These challenges hinder the effective use of digital tools such as simulations, multimedia content, and mobile learning platforms in science instruction. Using a descriptive survey design, data were collected from 80 science teachers and 200 senior secondary school students across urban and rural schools. The findings reveal a growing awareness and partial adoption of technology-enhanced teaching methods, particularly in urban areas. However, limited access to devices, unreliable electricity, and insufficient professional development remain significant barriers, especially in rural settings. The implications of these findings underscore the urgent need for targeted teacher training in digital pedagogy, strategic investment in ICT infrastructure, and curriculum reform that embeds technology competencies into science education. The study concludes that while technology holds transformative potential for science teaching, its impact will remain uneven without coordinated policy support and inclusive implementation strategies. It is recommended that stakeholders prioritize equitable resource distribution, develop localized digital content, and institutionalize continuous professional development to foster sustainable and inclusive pedagogical transformation in science education across Taraba State.

Keywords: Pedagogical Transformation, Science Education, Technology Integration, Instructional Materials, Taraba State

Introduction

The global shift toward technology-enhanced education has transformed science teaching into a more interactive, inquiry-driven, and student-centered experience. Digital tools such as simulations, virtual laboratories, mobile learning platforms, and multimedia content have been widely adopted to improve conceptual understanding and learner engagement (Akinwumi et al., 2025). These innovations align with 21st-century learning goals and have proven effective in fostering critical thinking and scientific literacy across diverse educational contexts.

In Nigeria, national education policies have emphasized the integration of Information and Communication Technology (ICT) into teaching and learning. However, implementation remains uneven, particularly in under-resourced regions like Taraba State. Despite policy frameworks and global advancements, science teaching in many secondary schools within the state continues to rely on traditional, teacher-centered methods. The low adoption of technology-driven instructional materials is primarily due to infrastructural deficits such as unreliable electricity, poor internet connectivity, and limited access to digital devices and a lack of professional development for science teachers (Agboola, 2025; Oluwatade, 2024).

These challenges not only hinder pedagogical innovation but also widen the digital divide between urban and rural schools. Teachers often lack the training and support needed to effectively integrate technology into their lessons, resulting in missed opportunities for student engagement and improved learning outcomes (Eze & Okonkwo, 2023). Addressing these gaps is essential for achieving equitable and future-ready science education in Taraba State.

This study therefore seeks to examine the current state of technology integration in science teaching, assess its impact on instructional practices, and propose actionable strategies for improvement. Grounded in constructivist and connectivist learning theories, the research contributes to the discourse on educational transformation in Nigeria.

Research Objectives

1. To assess the level of adoption of technology-driven instructional materials in science teaching across Taraba State.
2. To identify infrastructural and professional development challenges affecting technology integration.
3. To evaluate the impact of digital tools on teaching effectiveness and student engagement.
4. To recommend strategies for enhancing technology use in science education.

Research Questions

1. What is the current level of technology integration in science teaching in Taraba State?
2. What infrastructural and training challenges hinder the adoption of digital instructional materials?
3. How do technology-driven tools influence teaching effectiveness and student engagement?
4. What strategies can be implemented to improve technology integration in science education?
5.

Literature Review

Recent scholarship has emphasized the transformative potential of technology in science education, particularly within the context of STEM pedagogy in Nigeria. Chisom et al. (2024) conducted a comprehensive review of STEM education advancements, highlighting progress in curriculum development and teaching methodologies. Their findings revealed increased awareness of global standards but persistent challenges in teacher training, gender equity, and resource availability. Similarly, Amie-Ogan and Oguru (2025) examined the implementation of Nigeria's secondary STEM curriculum and identified critical barriers including inadequate funding, lack of qualified teachers, and insufficient instructional materials. Both studies underscore the need for systemic reform but focus primarily on national-level trends without delving into regional disparities.

Arabo et al. (2025) explored the integration of Artificial Intelligence (AI) in STEM education and workforce readiness. Their mixed-methods study revealed that while Nigeria's youthful population offers strategic potential, infrastructural deficits and outdated curricula hinder meaningful adoption of AI-enabled tools. The authors advocate for curriculum reform, teacher capacity-building, and digital literacy programs recommendations that align with broader calls for pedagogical innovation.

While these studies collectively affirm the importance of technology in science education, they lack localized insights into how these challenges manifest in specific regions like Taraba State. Taraba, characterized by rural-urban divides and infrastructural limitations, presents a unique context where national strategies may not translate effectively. Existing literature has not adequately addressed how regional disparities affect technology adoption in science teaching, nor has it explored the lived experiences of teachers and students navigating these constraints.

This study fills that gap by providing empirical evidence from Taraba State, offering a nuanced understanding of the barriers to ICT integration in science pedagogy. It contributes uniquely by linking infrastructural realities with pedagogical outcomes and proposing region-specific strategies for teacher training, curriculum reform, and equitable resource distribution.

Challenges and Opportunities in Taraba State

Taraba State offers a fascinating backdrop for exploring changes in science education. While some urban schools are starting to embrace digital tools, many rural schools struggle with the lack of infrastructure and technical support needed for successful integration. As noted by Chisom, et al. (2023), the gap in technology access across different Nigerian states has led to unequal learning experiences, leaving students in under-resourced areas at a significant disadvantage.

However, there is a silver lining. Mobile learning platforms, solar-powered devices, and community-driven digital initiatives are starting to bridge the gaps in connectivity and access. When these innovations are paired with focused teacher development programs, they have the potential to spark real change in science classrooms throughout Taraba State.

Methodology

Research Design

This study adopted a descriptive survey design to investigate the integration of technology-driven instructional materials in science teaching across secondary schools in Taraba State. The design was chosen to enable the collection of quantitative data from a broad population, allowing for generalization of findings and identification of patterns related to pedagogical practices and technology use.

Population and Sample Size

The target population comprised science teachers and senior secondary school students (SS1-SS3) across public secondary schools in Taraba State. A multistage sampling technique was employed to ensure representation across urban and rural schools. Using Taro Yamane's formula for sample size determination:

$$n = \frac{N}{1+N\,(e)^{2}}$$

Where:

- (n) = sample size

- (N) = population size

- (e) = margin of error (0.05)

From an estimated population of 100 science teachers and 500 students, the calculated sample sizes were 80 teachers and 200 students respectively. Stratified random sampling was used to select participants across school locations to ensure balanced representation.

Instrumentation

Two structured instruments were developed:

1. Teacher Questionnaire on Technology-Driven Instructional Materials in Science Education (TQ-TDIMSE)
2. Student Perception Survey on Digital Science Instruction (SPS-DSI)

Both instruments were subjected to expert validation by specialists in science education and educational measurement. A pilot test was conducted in two schools outside the main sample area to assess clarity, relevance, and reliability.

Reliability Analysis

Reliability was determined using Cronbach's alpha coefficient:

1. TQ-TDIMSE: $\alpha = 0.81$, indicating high internal consistency.
2. SPS-DSI: $\alpha = 0.78$, indicating acceptable reliability.

These values confirm that the instruments were suitable for data collection and capable of producing consistent results.

Results and Findings

This section dives into the data gathered from science teachers and students in selected secondary schools across Taraba State. The results are organized around key themes that popped up from both the quantitative and qualitative feedback.

1. Embracing Technology-Driven Instructional Materials

Table 1: Adoption of Technology-Driven Instructional Materials by Teachers

S/N	Technology Type	% of Teachers Using	Urban Schools	Rural Schools
1	Multimedia (videos, slides)	68%	High usage	Moderate usage
2	Mobile learning apps	45%	Moderate	Low
3	Virtual labs/simulations	22%	Limited	Rare
4	AI-based tools (e.g., tutoring)	10%	Emerging	Not available

Among the 80 science teachers surveyed, a notable 68% reported using at least one type of digital instructional material, like PowerPoint presentations, educational videos or mobile learning apps. However, only 22% had access to more advanced tools such as virtual laboratories or simulation software. Teachers in urban areas showed a higher adoption rate compared to those in rural settings, mainly due to better infrastructure and internet access.

These findings resonate with recent national studies that point out the uneven distribution of educational technologies across Nigerian states. Okunade (2024) highlights that while AI-based tools like Adaptive Learning Systems are becoming more popular, their availability is still limited in under-resourced areas.

2. Influence on Teaching Effectiveness

Table 2: Impact of Technology on Teaching Effectiveness

S/N	Statement	% Agreeing	Teacher Comments Summary
1	Technology simplifies complex concepts	76%	Simulations make atomic structure easier
2	Students are more engaged during tech-enhanced lessons	71%	They ask more questions and participate more
3	Technology improves lesson delivery and pacing	64%	I can cover more ground with visual aids
4	Tech use increases student performance in assessments	58%	Scores improved in topics taught with videos

Teachers who frequently utilized technology-driven materials noticed a boost in classroom engagement and a deeper understanding of concepts among their students. A significant 76% of respondents agreed that digital tools made it easier to grasp complex scientific ideas, especially in subjects like physics and chemistry. One teacher shared, "Using simulations to illustrate atomic structure has transformed my lessons into something more interactive and tangible."

This aligns with findings from Nkok and Chukelu (2025), who noted that curriculum reforms that integrate technology greatly improved teaching quality and student involvement in science subjects

3. Students' Perception and Engagement

Table 3: Students' Perception of Technology in Science Classes

S/N	Statement	% Agreeing	Urban Students	Rural Students
1	Prefer lessons with digital content	81%	Very high	Moderate
2	Technology helps understanding of difficult topics	74%	High	Moderate
3	Have access to digital devices for learning	66%	High	Low
4	Want more digital content in science classes	83%	Very high	High

Out of 200 students surveyed, a whopping 81% said they preferred lessons that included digital contents, noting that it sparked their interest and helped them remember better. Students in schools equipped with multimedia tools reported feeling more motivated and engaged. On the flip side, 34% of students from rural schools mentioned they had never used a computer or tablet during a science class, highlighting the significant digital divide in the state.

4. Challenges to Integration

Table 4: Challenges Faced by Teachers in Technology Integration

S/N	Challenge	% of Teachers Affected	Urban Schools	Rural Schools
1	Inadequate infrastructure	72%	Moderate	Severe
2	Lack of training in digital pedagogy	65%	Common	Very common
3	Irregular power supply	59%	Occasional	Frequent
4	Poor internet connectivity	53%	Manageable	Major barrier

Some key obstacles that were identified include; insufficient infrastructure (noted by 72% of teachers), a lack of training in digital teaching methods (65%), and unreliable power supply and poor internet connectivity, particularly in rural areas. These issues reflect those mentioned in the STEM Education Advancements in Nigeria report, which emphasizes the need for strategic policy changes to tackle resource shortages and enhance teacher training.

Discussion

Pedagogical Shifts in Science Teaching

The study revealed a gradual transition from traditional teacher-centered instruction to more interactive, technology-enhanced pedagogies in urban schools across Taraba State. Teachers reported increased use of multimedia tools, simulations, and mobile learning platforms to simplify abstract scientific concepts and foster student engagement. This aligns with the principles of constructivist theory, which emphasize active learning, knowledge construction, and contextual understanding (Jonassen, 2024). Digital tools enabled students to visualize processes, manipulate variables, and engage in inquiry-based learning—hallmarks of constructivist science education.

However, the shift remains uneven. In rural schools, limited access to digital resources has constrained pedagogical innovation, reinforcing rote learning and passive instruction. This disparity underscores the need for localized strategies to support technology integration in underserved areas.

Teacher Capacity and Professional Development

Findings showed that over 65% of science teachers had not received formal training in digital pedagogy. While many expressed willingness to adopt technology, their capacity to do so effectively was limited by a lack of technical skills and pedagogical support. This echoes the conclusions of Eze and Okonkwo (2023), who found that teacher readiness, is a critical determinant of successful ICT integration in Nigerian classrooms.

Constructivist teaching requires teachers to act as facilitators rather than transmitters of knowledge. Without adequate training, teachers struggle to design learner-centered activities or integrate digital tools meaningfully. Continuous professional development is therefore

essential to equip educators with the competencies needed for transformative science instruction.

Digital Divide and Infrastructure Challenges

The study highlighted stark urban-rural disparities in access to electricity, internet connectivity, and digital devices. While urban schools reported moderate infrastructure, rural schools faced severe limitations that hindered even basic technology use. This digital divide not only affects instructional delivery but also exacerbates educational inequality a concern echoed by Amie-Ogan and Oguru (2025), who emphasized the need for equitable resource distribution in STEM education.

Constructivist learning environments thrive on access to diverse tools and collaborative platforms. In Taraba State, infrastructural gaps prevent students from engaging in such environments, limiting their exposure to modern scientific practices and inquiry.

Policy Implications and Strategic Recommendations

The findings suggest that policy interventions must go beyond curriculum reform to address systemic barriers. While national education policies advocate ICT integration, implementation at the state level remains fragmented. There is a pressing need for coordinated efforts to improve infrastructure, institutionalize teacher training, and develop localized digital content tailored to the realities of Taraba State.

Arabo et al. (2025) argue that Nigeria's educational transformation depends on aligning policy with practice. For Taraba State, this means investing in solar-powered ICT labs, establishing teacher ICT hubs, and embedding digital literacy into science curricula. Such measures would not only support constructivist pedagogy but also prepare students for participation in a digitally-driven economy.

Conclusion

This study contributes valuable insights into the evolving landscape of science education in Taraba State, highlighting the uneven adoption of technology-driven instructional materials across urban and rural schools. By examining infrastructural gaps, teacher preparedness, and student engagement, the research provides evidence-based knowledge that can inform policymakers seeking to implement inclusive and effective ICT strategies in education.

For policymakers, the findings underscore the urgency of investing in digital infrastructure, especially in underserved regions, and institutionalizing professional development programs tailored to science educators. The study also reinforces the need for curriculum reform that embeds digital competencies and constructivist principles into science teaching frameworks.

For teachers, the study offers practical implications by identifying specific barriers to technology integration and emphasizing the importance of pedagogical shifts toward learner-centered, inquiry-based instruction. It encourages educators to adopt digital tools not merely as supplements but as transformative instruments for enhancing scientific literacy and engagement.

Future research should explore longitudinal impacts of technology adoption on student learning outcomes, retention, and performance in science subjects. Such studies would provide deeper insights into the sustained effectiveness of digital pedagogy and guide long-term policy and instructional decisions.

Ultimately, this study lays the groundwork for a regionally responsive, equity-driven approach to science education reform in Nigeria.

Recommendations

1. Train at least 60% of science teachers in ICT integration within two academic sessions: The Ministry of Education, in collaboration with teacher training colleges and NGOs, should implement targeted digital pedagogy workshops and certification programs for science teachers. Progress should be tracked through attendance records and post-training evaluations.
2. Equip 50% of public secondary schools in Taraba State with solar-powered ICT labs by the end of the third academic session: Given the region's electricity challenges, solar-powered labs offer a sustainable solution. Implementation should prioritize rural schools and be monitored through infrastructure audits and usage reports.
3. Embed digital literacy and constructivist teaching strategies into the science curriculum revision scheduled for the next curriculum cycle (within 18 months): Curriculum developers should integrate technology-based inquiry learning, simulations, and collaborative tools into science syllabi, ensuring alignment with national STEM goals.
4. Develop and deploy localized digital instructional materials for core science subjects in at least 40% of schools within two years: These materials should reflect local contexts, languages, and curriculum standards. Content creation teams should include science educators, instructional designers, and digital media experts.
5. Establish a monitoring and evaluation framework to assess ICT integration progress annually: This should include teacher feedback, student performance metrics, and infrastructure usage data. Reports should be submitted to the State Education Board to inform future policy decisions.

These recommendations are rooted in recent research and policy frameworks that advocate for a future-ready, inclusive, and digitally empowered science education system in Nigeria.

References

Akinwumi, M. O., Ariyo, J. K., & Ademola, M. D. (2025). Transforming education in Nigeria through science, technology and innovation: Opportunities and challenges. *Asian Journal of Education and Social Studies, 51(8), 984–995.* Retrieved from https://doi.org/10.9734/ajess/2025/v51i82295

Agboola, O. S. (2025). Science education in Nigeria: The emergence, challenges and expectations [Inaugural lecture]. Obafemi Awolowo University Press. Retrieved from https://oauife.edu.ng/wp-content/uploads/2025/02/392nd-Inaugural.pdf

Amie-Ogan, O. T., & Oguru, C. (2025). Secondary education STEM curriculum implementation in Nigeria: Prospects and challenges. *International Journal of Scientific Research in Education, 18(2), 204–212.* Retrieved from https://ijsre.com.ng/assets/vol.%2c-18%282%29-amie-oganoguru.pdf

Arabo, I., Ahmed, Y., & Abdulmalik, A. (2025). The impact of AI on STEM education and workforce readiness in Nigeria. *International Journal of Computer Science and Modern Technology, 11(6), 74–86.* Retrieved from https://iiardjournals.org/get/IJCSMT/VOL.%2011%20NO.%206%202025/The%20Impact%20%20AI%20on%20STEM%2074-86.pdf

Chisom, O. N., Unachukwu, C. C., & Osawaru, B. (2024). STEM education advancements in Nigeria: A comprehensive review. *International Journal of Applied Research in Social Sciences, 5(10), 614–636.* Retrieved from https://doi.org/10.51594/ijarss.v5i10.724

Eze, C. A., & Okonkwo, I. C. (2023). Teachers' readiness for digital integration in Nigerian secondary schools: A case study of science educators. *Journal of Educational Technology and Innovation, 6(2), 45–58.* Retrieved from https://doi.org/10.5281/zenodo.10456239

Jonassen, D. H. (2024). Learning to solve problems with technology: A constructivist perspective (3rd ed.). Routledge.

Oluwatade, P. (2024, October 1). The impact of technology on education in Nigeria: Benefits and challenges. Edusko Blog. Retrieved from https://www.edusko.com/blog/the-impact-of technology-on-education-in-nigeria-benefits-and-challenges