INTEGRATING ICT INTO SCIENCE AND TECHNOLOGY EDUCATION IN TERTIARY INSTITUTIONS IN BENUE STATE, NIGERIA: BRIDGING RESEARCH AND PRACTICE

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Abstract

Globally, information and communication technology (ICT) has emerged as a crucial instrument for revolutionizing research, teaching, and learning in higher education. ICT tools like learning management systems, digital databases, simulation software, and virtual laboratories have improved instructional delivery and students' conceptual grasp of complex scientific phenomena in science and technology education. However, because of institutional, pedagogical, and infrastructure issues, ICT integration in Nigerian postsecondary institutions is still uneven. With a focus on bridging the gap between research findings and classroom practice, this paper investigates the integration of ICT into science and technology education in tertiary institutions in Benue State, Nigeria, with a focus on closing the gap between research results and instructional strategies. The article addresses how ICT is changing science and technology education, emphasizes the advantages and difficulties of adopting ICT, and examines pertinent research on technology integration in Nigerian higher education. The paper also suggests methods for incorporating research findings into instructional practice and identifies best practices for ICT implementation. The study comes to the conclusion that better infrastructure, ongoing professional development for instructors, supportive institutional policies, and increased cooperation among education sector stakeholders are necessary for sustainable ICT integration.

Keywords: Digital learning, ICT integration, Nigeria, science education, research practice gap, tertiary education

Introduction

Education systems have been greatly impacted by the global spread of information and communication technology (ICT), especially in science and technology education where digital tools improve experimentation, visualization, and group learning. ICT is now a crucial part of contemporary higher education because it makes creative teaching methods possible, increases information accessibility, and boosts research output. Higher education institutions are expected to provide graduates with the disciplinary knowledge and digital skills required for technological advancement as societies shift more and more towards knowledge-based economies.

In order to enhance teaching and learning outcomes, higher education institutions all over the world have recently embraced ICT tools like virtual laboratories, simulation software, learning management systems, artificial intelligence platforms, and digital communication technologies. With the use of these technologies, teachers can design interactive classrooms that encourage critical thinking, inquiry-based learning, and group problem solving (Abubakar, Ogunlade, & Ibrahim, 2024). In light of its potential to improve educational quality and global competitiveness, policymakers and educational stakeholders in Nigeria are paying more attention to the integration of ICT in tertiary education. Nigerian colleges of education, polytechnics, and universities are supposed to produce graduates who can successfully engage in a technology-driven economy. But even with the acknowledged value of ICT in higher education, a lot of Nigerian institutions still have a hard time putting technology-enhanced teaching and learning into practice. Numerous postsecondary institutions, such as universities, polytechnics, and colleges of education, are found in Benue State, which is in North Central Nigeria. These establishments support the growth of scientific and technological personnel. Future scientists, engineers, and educators who will spearhead national development are trained in large part by these institutions. However, due to inadequate institutional support, inadequate digital skills among educators, and inadequate infrastructure, the successful integration of ICT into science and technology education in many state institutions is still restricted.

Although ICT facilities like projectors, digital communication systems, and computer technologies are progressively being introduced into universities, research from North-Central Nigeria shows that their use in teaching and administration is still comparatively low (Okpe, 2025). This circumstance emphasizes the need for more effective methods to close the gap between ICT integration research and its actual application in higher education. Thus, the

integration of ICT in science and technology education at tertiary institutions in Benue State, Nigeria, is examined in this paper with an emphasis on how research findings can guide successful teaching strategies.

The Role of ICT in Transforming Science and Technology Education in Tertiary Institutions in Benue State

By facilitating access to global knowledge resources, improving research activities, and enabling innovative teaching methods, ICT plays a transformative role in science and technology education. Science instruction in conventional classroom settings heavily relies on lectures and printed materials. However, by utilizing digital simulations, interactive learning platforms, and multimedia resources, ICT tools enable educators to go beyond these methods. Optimizing the visualization of intricate scientific procedures is one of ICT's main contributions to science education. It is challenging to illustrate many scientific ideas using conventional teaching techniques, such as molecular interactions, ecological dynamics, and physical phenomena. Students can watch these processes in virtual settings through digital simulations and animations, which improve their conceptual knowledge and scientific reasoning. Additionally, ICT makes it easier to create virtual labs where students can carry out digital experiments. Without the constraints of physical laboratory resources, learners can manipulate experimental variables, repeat procedures, and analyze data in virtual laboratories. This is especially crucial in many Nigerian schools where there is frequently not enough lab equipment to accommodate large student populations.

Additionally, by giving tertiary institutions access to digital libraries, online journals, and international scientific databases, ICT improves research activities. These platforms allow lecturers and students to collaborate with academics from different institutions, access recent research findings, and take part in global academic networks. Another important role of ICT is supporting collaborative learning. Digital communication tools such as online discussion forums, video conferencing platforms, and collaborative document editing systems allow students and lecturers to engage in interactive academic discussions beyond the classroom environment.

In Benue State, research conducted at Joseph Sarwuan Tarka University revealed that the availability and utilization of ICT facilities significantly influence teaching effectiveness and students' learning experiences in higher education institutions (Akaa et al., 2024). These findings suggest that expanding ICT infrastructure and training educators in digital pedagogy could substantially improve science and technology education in the state.

Benefits of ICT Integration in Science and Technology Education

The following are the key benefits associated with integrating ICT into science and technology education:

1. **Outcomes:** ICT integration enhances the effectiveness of instructional delivery in science and technology education. Multimedia presentations, digital simulations, and interactive learning platforms enable educators to present complex scientific concepts in ways that are easier for students to understand. Research has shown that technology-integrated curriculum resources improve student engagement and academic achievement in higher education settings (Abubakar et al.2024). When students interact with digital simulations and virtual laboratories, they are more likely to develop deeper conceptual understanding and stronger problem-solving skills.
2. **Increased Student Engagement and Motivation:** Digital learning environments often encourage active participation and collaborative learning. ICT tools allow students to explore scientific concepts independently, conduct research online, and participate in virtual discussions with peers and lecturers.
3. **Promotion of Inquiry Based Learning:** Digital technologies support inquiry-based learning by enabling students to conduct virtual experiments, analyze scientific data, and explore multiple solutions to scientific problems. This approach aligns with contemporary pedagogical practices in science education.
4. **Improved Access to Learning Resources:** ICT enables students and educators to access a wide range of educational resources, including digital textbooks, online journals, research databases, and open educational resources. This access helps bridge the gap between local educational institutions and global scientific knowledge.
5. **Development of Digital Competencies:** ICT integration equips students with digital literacy skills that are essential for scientific research and technological innovation. These competencies include data analysis, information management, programming, and online collaboration.
6. **Enhanced Research Productivity:** ICT tools facilitate data collection, analysis, and dissemination of research findings. Digital research tools enable scholars to collaborate with researchers across institutions and countries, thereby enhancing knowledge exchange and academic productivity. It equally provides Access to online databases, digital

libraries, and research collaboration platforms that enable lecturers and students to conduct high quality scientific research and remain updated with global scientific developments.

Challenges of ICT Integration in Tertiary Institutions

Despite the numerous benefits of ICT integration, several challenges hinder its effective implementation in tertiary institutions in Nigeria.

1. **Inadequate ICT Infrastructure:** One of the most significant barriers to ICT integration is the limited availability of technological infrastructure. Many institutions lack adequate computer laboratories, reliable internet connectivity, and digital learning platforms necessary for effective technology-enhanced instruction.
2. **Limited Digital Skills among Educators:** Another major challenge is the insufficient digital competence among lecturers. Many educators have limited training in the pedagogical use of ICT tools, which reduces their ability to integrate technology effectively into teaching practices.
3. **Funding Constraints:** The acquisition and maintenance of ICT infrastructure require substantial financial investment. Many tertiary institutions in Nigeria operate under limited budgets, making it difficult to procure modern technological equipment and maintain digital learning systems.
4. **Electricity Instability:** Irregular power supply remains a major obstacle to ICT utilization in many Nigerian institutions. Without reliable electricity, digital technologies cannot function effectively in classrooms and laboratories.
5. **Policy Implementation Gaps:** Although Nigeria has developed policies supporting ICT integration in education, the implementation of these policies often remains inconsistent across institutions.

Studies conducted in Benue State also highlight the presence of technological barriers that limit effective ICT adoption in science teaching environments, including inadequate facilities and insufficient training for educators (Chukwu, 2016)

1. **Curriculum Innovation:** Science and technology curricula should incorporate ICT-based instructional strategies such as virtual laboratories, simulation-based learning, and online collaborative platforms.
2. **Institutional Policy Support:** Clear institutional policies should guide the integration of ICT into teaching, research, and administrative processes.

3. **Collaboration and Partnerships:** Partnerships with technology companies, international organizations, and research institutions can support ICT infrastructure development and innovation in science education.

Theoretical Framework

Theoretical models that explain how technology interacts with pedagogy and content knowledge are frequently used to explain the integration of information and communication technology (ICT) in education. The Technology Acceptance Model (TAM) and the Technological Pedagogical Content Knowledge (TPACK) framework are two popular frameworks that describe ICT integration in educational settings.

Technological Pedagogical Content Knowledge (TPACK) Framework

Mishra &Koehler (2006) created the Technological Pedagogical Content Knowledge (TPACK) framework to describe how educators successfully incorporate technology into their lessons. According to the framework, when educators integrate three types of knowledge: technological, pedagogical, and content knowledge, effective technology integration takes place (Mishra & Koehler, 2006).

While pedagogical knowledge relates to the techniques and approaches used to deliver instruction, content knowledge refers to teachers' comprehension of the subject matter they teach. The ability to effectively use digital tools and technologies in teaching and learning processes is referred to as technological knowledge.

The TPACK framework highlights that in order to improve students' learning experiences in science and technology education, instructors must not only comprehend scientific concepts but also know how to use technological tools like simulations, digital laboratories, and data analysis software. Research indicates that teachers with high TPACK competencies are more likely to successfully incorporate ICT into their lesson plans (Chai et al., 2020). The TPACK framework emphasizes the value of enhancing instructors' pedagogical and technological skills in addition to their subject matter expertise for Benue State's postsecondary institutions.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Fred D. Davis, explains how users adopt and accept new technologies. According to TAM, two major factors determine whether individuals adopt a technological innovation: perceived usefulness and perceived ease of use (Davis, 1989).

Perceived usefulness refers to the extent to which an individual believes that using a particular technology will improve job performance, while perceived ease of use refers to the degree to which the technology is perceived as simple and effortless to use.In the context of ICT integration in tertiary education, lecturers are more likely to adopt digital technologies if they believe that these technologies will enhance their teaching effectiveness and if they find the tools easy to use. Research conducted in Nigerian universities shows that lecturers' attitudes toward technology significantly influence their willingness to integrate ICT into instructional practices (Awofala, 2021). By combining the TPACK and TAM frameworks, this paper provides a comprehensive explanation of both the pedagogical competence required for ICT integration and the behavioral factors influencing technology adoption among educators.

When it comes to ICT integration in higher education, instructors are more likely to use digital tools if they think they will improve their effectiveness as teachers and if they find them user-friendly. According to Awofala (2021) instructors' attitudes toward technology have a big impact on how willing they are to incorporate ICT into their teaching methods. This paper offers a thorough explanation of the behavioral factors influencing educators' adoption of technology as well as the pedagogical competence necessary for ICT integration by combining the TPACK and TAM frameworks.

Some Previous Works on ICT Integration in Higher Education

Due to its potential to revolutionize teaching, learning, and research processes, ICT integration in higher education has been extensively researched worldwide. ICT has emerged as a vital tool for raising research productivity, encouraging inquiry-based learning, and strengthening students' conceptual understanding in science and technology education in particular. The use of digital technologies like artificial intelligence, big data analytics, and simulation tools has greatly enhanced teaching and learning in higher education institutions, according to recent studies. For instance, students view AI-supported learning environments as helpful for enhancing academic engagement and learning outcomes, according to a study on the integration of AI in Nigerian higher education institutions (Abubakar et al., 2024). The Fourth Industrial Revolution's digital technologies, such as robotics, artificial intelligence, and data analytics, are crucial for enhancing science education and preparing graduates for global technological competitiveness, according to research on STEM education in Nigerian universities (Ekwu et al., 2024).

Numerous studies conducted in Nigeria have also looked at the difficulties associated with ICT integration in higher education. For example, Anike (2024) noted that ICT use in Nigerian higher education institutions improves research

activities and knowledge access, but it is frequently impeded by infrastructure constraints and teachers' lack of technical expertise. Research on the use of ICT in university administration in North-Central Nigeria revealed that, despite the gradual introduction of ICT facilities in universities, their effective utilization is still relatively low because of insufficient institutional support and training (Okpe, 2025).

Additionally, research on Benue State shows that inadequate technical proficiency among teachers and a lack of ICT facilities continue to hinder the successful integration of ICT in science education. Science teachers in Benue State face a number of obstacles when attempting to incorporate ICT-based instructional strategies into their teaching practices, according to Chukwu (2016). These obstacles include a lack of equipment, inadequate training, and an unreliable power supply.

ICT integration in postsecondary institutions is impacted by wider student digital skill gaps in addition to institutional issues. This issue has been addressed by initiatives like Benue State's "One Student, One Computer, One Digital Skill" program, which gives students access to computers and training in digital skills to get them ready for the modern workforce.

Recent studies (Awofala, (2022), Adamu& Umar (2022), Okoye & Nwoye (2022), Akaa *et al* (2024), and Ekwu*et al* (2025) also emphasize that ICT integration plays a critical role in transforming science and technology education across higher education institutions worldwide. Researchers in Nigeria have been looking more closely at how digital technologies affect research productivity, student learning outcomes, and the efficacy of instruction.

A study conducted by Adamu& Umar (2022) found that ICT-supported teaching strategies significantly improve students' academic achievement in science subjects in Nigerian universities. The researchers observed that digital simulations and multimedia learning tools enhance students' understanding of abstract scientific concepts. Similarly, Awofala (2021) reported that technology based instructional strategies improve students' motivation and engagement in science learning environments. The study emphasized that ICT integration promotes active learning and collaborative problem solving among students.

In another study focusing on Nigerian tertiary institutions, Yusuf and Balogun (2020) noted that ICT tools such as learning management systems, virtual laboratories, and online research databases have improved access to scientific knowledge and enhanced research productivity among academics. Despite these benefits, several studies have highlighted the persistent challenges affecting ICT

integration in Nigerian tertiary institutions. For example, Okoye and Nwoye (2022) identified inadequate infrastructure, unreliable electricity supply, and insufficient technical support as major barriers to technology adoption in universities.

Within Benue State, research conducted by Akaa et al. (2024) at Joseph Sarwuan Tarka University revealed that although ICT facilities exist in many departments, their utilization in teaching remains limited due to insufficient training for lecturers and limited institutional support. Similarly, Okoye and Nwoye (2022) found that science educators in Benue State encounter multiple challenges when attempting to integrate ICT into teaching, including lack of equipment, inadequate digital skills, and limited access to internet services.

International research also supports the transformative potential of ICT in science education. According to UNESCO (2023), digital technologies can significantly enhance science education by providing interactive learning environments, facilitating global collaboration among researchers, and improving access to scientific resources.

Collectively, these studies demonstrate that while ICT has significant potential to improve science and technology education, effective implementation requires addressing both infrastructural and pedagogical challenges. Overall, the literature suggests that while ICT has significant potential to transform science and technology education, its successful implementation requires adequate infrastructure, strong institutional policies, and continuous capacity building for educators.

Best Practices for ICT Integration in Science and Technology Education

To ensure effective integration of ICT in tertiary institutions, several best practices have been identified in educational research and policy frameworks as follows:

1. **Institutional ICT Policy Development:** Institutions should develop comprehensive ICT policies that guide the integration of digital technologies in teaching, research, and administration. These policies should clearly outline the responsibilities of institutional leaders, lecturers, and technical staff in promoting technology enhanced learning.
2. **Professional Development for Lecturers:** Continuous professional development programs are essential for equipping lecturers with the skills required to effectively integrate ICT into teaching. Training workshops and digital pedagogy programs can help educators learn how to use virtual laboratories, simulation tools, and learning management systems.
3. **Infrastructure Development:** Adequate technological infrastructure including computers, internet connectivity, digital laboratories, and

learning management systems is necessary for successful ICT integration. National initiatives such as the Tertiary Institution Digital Centers project which aim to establish ICT centers in universities to improve digital learning and innovation.

4. **Curriculum Integration:** ICT competencies should be embedded into science and technology curricula so that students acquire digital literacy and technological skills alongside disciplinary knowledge.
5. **Collaboration with Industry and Technology Partners:** Partnerships with technology companies, research institutions, and government agencies can help universities access modern digital tools and training opportunities.
6. **Development of Virtual Laboratories:** Virtual laboratories allow students to conduct experiments digitally and repeat procedures without the limitations of physical laboratory resources. These platforms are particularly beneficial for institutions with limited lab oratory equipment.
7. **Adoption of Blended Learning Models:** Blended learning combines traditional face-to-face instruction with online learning activities. This approach allows students to access instructional materials online while still benefiting from classroom interaction with lecturers.
8. **Open Educational Resources (OER):** Open educational resources provide free access to digital textbooks, lecture materials, and research publications. Integrating OER into science education can help reduce the cost of instructional materials and improve access to quality educational resources.
9. **Institutional Research and Innovation Centers:** Universities should establish innovation hubs and digital research centers that encourage students and lecturers to develop technology driven solutions to societal challenges.

Bridging Research and Practice

One of the major challenges in educational innovation is the gap between research findings and actual classroom practice. Although numerous studies highlight the benefits of ICT integration in education, many institutions struggle to translate these research findings into effective teaching practices. Bridging this gap requires stronger collaboration among researchers, educators, and policymakers. Research findings should be communicated in ways that are accessible and applicable to classroom teaching. Institutions should also encourage evidence-based teaching

practices by integrating research outcomes into curriculum development and instructional design.

Professional learning communities can also play an important role in bridging research and practice. These communities allow educators to share experiences, discuss challenges, and develop innovative teaching strategies using ICT.

In addition, institutional leadership is essential for promoting the adoption of research-based practices. University administrators should support ICT integration by providing funding for technological infrastructure and organizing training programs for lecturers.

Implications for Tertiary Institutions in Benue State

The integration of ICT in science and technology education has several implications for tertiary institutions in Benue State. Firstly, institutions must prioritize the development of ICT infrastructure to support digital teaching and research activities. Modern computer laboratories, reliable internet connectivity, and digital learning platforms are essential for effective technology enhanced education. Secondly, there is a need for continuous capacity building programs that enhance lecturers' digital competencies. Educators must be trained not only in basic computer skills but also in the pedagogical use of digital technologies for teaching science and technology subjects. Thirdly, institutional policies should encourage the adoption of innovative teaching strategies that incorporate digital tools such as virtual laboratories, simulation software, and artificial intelligence applications. Finally, collaboration between government agencies, educational institutions, and private technology companies can support the development of sustainable ICT ecosystems in tertiary institutions across the state.

For tertiary institutions in Benue State, effective ICT integration has several long-term implications. Firstly, ICT enhanced education can improve the quality of science and technology training, thereby producing graduates who are better prepared for careers in research, industry, and entrepreneurship. Secondly, ICT integration can enhance research productivity in universities by providing access to global research databases and facilitating collaboration among scholars. Thirdly, digital learning technologies can help institutions manage increasing student enrollment by supporting online and blended learning models.

Finally, strengthening ICT integration can position tertiary institutions in Benue State as centers of innovation and technological advancement within Nigeria.

Conclusion

ICT integration represents a powerful tool for transforming science and technology education in tertiary institutions. Digital technologies provide opportunities for improving teaching effectiveness, enhancing students' learning experiences, and expanding research capabilities. However, the effective integration of ICT in tertiary institutions in Benue State faces several challenges, including inadequate infrastructure, limited digital competencies among educators, funding constraints, and policy implementation gaps. Addressing these challenges requires a coordinated effort involving government agencies, educational institutions, educators, and technology partners. By investing in digital infrastructure, strengthening institutional policies, and promoting continuous professional development for educators, tertiary institutions in Benue State can bridge the gap between research and practice in ICT integration. Ultimately, effective ICT integration will not only improve science and technology education but also contribute to the development of a technologically skilled workforce capable of driving national development.

Recommendations

1. Government should increase funding for ICT infrastructure in tertiary institutions across Benue State.
2. Universities and colleges should organize regular training programs to improve lecturers' digital teaching competencies.
3. ICT competencies should be integrated into science and technology curricula to enhance students' digital literacy.
4. Institutions should establish partnerships with technology companies and research organizations to support digital innovation.
5. Institutional leaders should develop clear policies that encourage the use of ICT in teaching, research, and administration.

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