
TECHNOLOGY INTEGRATION IN MATHEMATICS EDUCATION: IMPLICATIONS ON STUDENTS' LEARNING AND ENGAGEMENT

BY

GEORGE, Nchelem Rosemary

DEPARTMENT OF MATHEMATICS

IGNATIUS AJURU UNIVERSITY OF EDUCATION, PORT HARCOURT, RIVERS
STATE, NIGERIA

&

NWODO, John Ibekwe

DEPARTMENT OF CURRICULUM & INSTRUCTIONAL TECHNOLOGY

IGNATIUS AJURU UNIVERSITY OF EDUCATION, PORT HARCOURT, RIVERS
STATE NIGERIA

ABSTRACT

This study examined technology integration in mathematics education and its implications for students' learning and engagement. The integration of digital tools such as interactive software, dynamic geometry applications, graphing calculators, and online learning platforms has transformed mathematics instruction from traditional teacher-centered delivery to interactive and student-centered learning environments. Despite this potential, challenges persist in many schools, including inadequate infrastructure, limited teacher competence, and inconsistent implementation. The objectives of the study were to identify types of technology integration in mathematics education, determine their influence on students' engagement and participation, assess their effects on learning outcomes, and examine the challenges faced by teachers and students. Anchored on the Technology Acceptance Model (TAM), the study emphasized the importance of perceived usefulness and perceived ease of use in shaping technology adoption among teachers and learners. The conceptual review highlights technology integration as a pedagogical process that enhances visualization, collaboration, and personalized learning, while students' engagement reflects their behavioral, emotional, and cognitive involvement in mathematical activities. The findings from reviewed empirical studies revealed that effective technology integration significantly enhances students' conceptual understanding, motivation, participation, and academic performance. However, infrastructural gaps, poor digital literacy, and inadequate training hinder widespread adoption. The study concluded that technology integration positively influences students' learning and engagement when supported with adequate resources and pedagogical competence. The study suggested improved provision of ICT facilities, capacity building for mathematics teachers, and the implementation of supportive ICT policies to strengthen technology-driven mathematics education.

Keywords: Technology, Mathematics Education, Integration, Students, Engagement.

Introduction

In the 21st century, education has increasingly been shaped by rapid advancements in information and communication technology (ICT), which have transformed teaching and learning processes across various disciplines, including mathematics. Modern educational systems now emphasize digital literacy, innovation, and interactive learning environments that equip students with the skills needed to function effectively in a technology-driven society. Within this context, technology integration in mathematics education refers to the purposeful incorporation of digital tools and technological resources, such as interactive whiteboards, dynamic geometry software, graphing calculators, computer-based tutorials, and online learning platforms, into mathematics instruction to enhance teaching effectiveness and improve students' learning experiences. This integration shifts mathematics instruction from the traditional teacher-centered "chalk-and-talk" approach to a more interactive, student-centered, and inquiry-based learning environment where learners actively explore mathematical concepts through visualization, simulations, and problem-solving activities. By enabling students to manipulate variables, analyze graphical representations, and receive immediate feedback, technology helps make abstract mathematical concepts more concrete and understandable. Mathematics is no longer perceived as a rigid or intimidating subject but as an interactive and dynamic discipline that connects theory with real-life applications (Anihenya & Agah, 2021). Technology has become an essential tool for comprehending basic mathematics concepts in today's world (Charles-Ogan, 2016).

Consequently, technology integration not only improves conceptual understanding and retention but also enhances students' motivation, engagement, and participation in mathematics learning, thereby aligning mathematics education with the demands and expectations of 21st-century education (Mohammed et al., 2025). Furthermore, technology enhances student engagement by promoting active participation, collaboration, and inquiry-based learning. When students use digital tools to manipulate mathematical data or explore graphical relationships, they take ownership of their learning process. This level of engagement fosters curiosity, critical thinking, and creativity, all of which are essential for developing higher-order cognitive skills. Interactive technologies such as GeoGebra, Desmos, and online quizzes also provide immediate feedback, helping students identify misconceptions and self-correct their errors in real time. Such feedback mechanisms increase motivation and encourage persistence in solving mathematical problems (Okafor & Olatunji, 2023). Technology integration has been shown to have a significant positive effect on students' academic performance in mathematics when effectively implemented. The use of digital tools such as interactive software, dynamic geometry programs (e.g., GeoGebra), and online learning platforms enhances students' conceptual understanding and problem-solving skills. These technologies allow learners to visualize abstract mathematical concepts, engage in simulations, and receive instant feedback, which fosters deeper comprehension and retention of mathematical ideas (Okonkwo & Nwosu, 2023).

Adebayo (2020) asserted that students who learn mathematics through technology-assisted instruction tend to perform better in assessments compared to those taught using traditional lecture methods. Technology also supports differentiated instruction, allowing teachers to tailor lessons to students' varying levels of ability and learning pace, thereby improving overall achievement and reducing performance gaps among learners. As a result, technology integration has a profound influence on students' learning outcomes in mathematics in Nigerian secondary schools by enhancing conceptual understanding, retention, and problem-solving abilities. The use of digital tools such as computer-based tutorials, graphing calculators, simulation software, and interactive whiteboards makes abstract mathematical concepts more tangible and easier to comprehend (Olojede & Adeoye, 2021). Through

technology-supported instruction, students can visualize complex equations, manipulate variables in real time, and receive immediate feedback, which promotes deeper learning and self-assessment. Eze and Okorie (2022), opined that learners exposed to technology-integrated mathematics lessons perform better in both class assessments and standardized examinations compared to those taught through conventional lecture methods. Any organization that does not incorporate the use of new technology in schools cannot claim to prepare their students for life in the 21st century (George & Charles-Ogan, 2023). This improvement stems from increased learner motivation, personalized learning experiences, and the ability of technology to accommodate different learning paces and styles. Mathematics is a subject which has found its relevance and application to almost all activities of life. This may suggest why George & Zalmon (2019) opined that Mathematics should be taught using innovative methods.

Technology integration in mathematics education has become an essential component of modern teaching, yet its implementation continues to present significant challenges that undermine its expected benefits. Although digital tools such as interactive software, learning management systems, and virtual manipulatives have the potential to enhance students' understanding of complex mathematical concepts, many mathematics classrooms still rely heavily on traditional teaching methods. This gap between technological availability and practical classroom integration creates a mismatch between curriculum expectations and actual instructional practices. As a result, students often fail to experience the enriched learning environment that technology is meant to provide, limiting their opportunities for deeper conceptual understanding and meaningful engagement with mathematics. In many public secondary schools, particularly in developing contexts such as Nigeria, obstacles such as inadequate technological infrastructure, lack of regular electricity supply, insufficient teacher training, and limited access to digital devices hinder effective technology integration in mathematics classrooms. Even when technologies are available, teachers may lack the competence or confidence to incorporate them into lesson delivery in ways that promote student-centered learning. Consequently, technology tends to be underutilized, misused, or applied superficially without aligning it to pedagogical goals. This often results in minimal improvement in learning outcomes and reduced student engagement, as students do not benefit from interactive and exploratory learning experiences that technology is capable of offering. Mathematics is an abstract subject and needs to be learnt by doing rather than by recalling or memorization (Odili, 2006).

Furthermore, despite the growing emphasis on technology-driven education, there is insufficient empirical evidence within many educational systems to demonstrate how technology integration directly influences students' learning outcomes and classroom engagement in mathematics. The inconsistent findings in existing studies raise questions about the actual impact of technological tools on students' motivation, participation, and academic performance. Some students become more engaged through interactive learning technologies, while others struggle due to cognitive overload, digital distractions, or lack of adequate digital literacy skills. This ambiguity highlights a critical gap that necessitates a deeper investigation into the implications of technology integration for students' learning and engagement in mathematics education. Understanding these implications is essential for informing policy decisions, improving teaching practices, and ensuring that investments in educational technology translate into meaningful learning experiences for students.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) was developed by Fred Davis in 1986 as an adaptation of the Theory of Reasoned Action (TRA) proposed by Fishbein and Ajzen in 1975.

The model was created to explain and predict users' acceptance and use of technology in various contexts, particularly within organizational and educational environments. Technology Acceptance Model (TAM) posits that two main factors such as Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) determine an individual's attitude toward technology adoption. Perceived Usefulness refers to the degree to which a person believes that using a particular technology will enhance their performance, while Perceived Ease of Use relates to how effortless they believe the technology is to operate. The model assumes that if a user perceives a technology as both useful and easy to use, they are more likely to develop a positive attitude toward it, leading to actual usage behavior (Davis, 1989). The key assumptions of Technology Acceptance Model (TAM) are that individuals act rationally and base their decisions to use technology on cognitive evaluations of its benefits and challenges. It assumes that users' behavioral intentions are influenced by their attitudes toward the technology and by their perceptions of its usefulness and ease of use. Technology Acceptance Model (TAM) also assumes that external variables—such as system design, organizational support, and individual differences—affect both perceived usefulness and ease of use.

In the context of technology integration in mathematics education in secondary schools, the Technology Acceptance Model (TAM) provides a useful framework for understanding how teachers and students adopt and utilize technological tools in the teaching and learning process. If mathematics teachers perceive educational technologies such as GeoGebra, Desmos, or digital projectors—as useful for improving student comprehension and classroom engagement, and if they find these tools easy to use, they are more likely to incorporate them into their lessons. Similarly, students who find technology-based learning platforms engaging and accessible are more inclined to participate actively in the learning process. Thus, Technology Acceptance Model (TAM) explains that enhancing both the perceived usefulness and ease of use of educational technologies through adequate training, infrastructure, and support can significantly improve technology acceptance, leading to better learning outcomes and increased engagement among students.

Technology Integration

Technology integration refers to the effective incorporation of digital tools, resources, and technological systems into teaching and learning processes to enhance educational outcomes. It involves using technology such as computers, interactive whiteboards, projectors, tablets, educational software, and the internet to support, enrich, and extend classroom instruction (Roblyer & Doering, 2019). Technology integration goes beyond the mere use of devices; it entails aligning technological applications with curriculum objectives and pedagogical strategies to improve students' understanding, engagement, and problem-solving skills. In the context of mathematics education, technology integration means embedding digital tools like graphing calculators, mathematical simulations, dynamic geometry software (e.g., GeoGebra), and online learning platforms into lesson delivery to make mathematical concepts more visual, interactive, and accessible to learners (Okojie et al., 2020). When effectively implemented, technology integration transforms traditional teaching methods into more student-centered approaches, promoting active learning and critical thinking among students.

Students' Learning and Engagement

Students' learning and engagement refers to the degree of attention, curiosity, interest, motivation, and active participation that learners exhibit during the learning process, which directly influences their academic achievement and overall educational experience. Learning involves the acquisition of knowledge, skills, attitudes, and values through study, instruction,

or experience, while engagement represents the emotional, behavioral, and cognitive involvement of students in learning activities (Fredricks et al., 2014). In essence, students' learning and engagement capture how deeply learners are involved in understanding course content and how effectively they apply learned concepts to solve problems. In mathematics education, students' engagement encompasses their willingness to participate in problem-solving exercises, discussions, and interactive activities that promote critical thinking and conceptual understanding. When technology is integrated into teaching, engagement often improves because digital tools make abstract mathematical concepts more concrete and interactive, thus enhancing motivation and comprehension (Trowler, 2020). Therefore, fostering students' learning and engagement involves creating supportive learning environments that combine effective pedagogy, technology, and feedback mechanisms to sustain learners' interest and promote meaningful academic growth.

Types of Technology Integration in Mathematics Education

Technology integration in mathematics education can take several forms, each serving distinct instructional purposes and enhancing the teaching–learning process in unique ways.

- i. **Instructional Technology:** Instructional technology refers to tools that support the delivery of mathematics content in the classroom. These include projectors, interactive whiteboards, digital textbooks, educational videos, and presentation software. Teachers use these tools to visualize abstract mathematical concepts, demonstrate procedures, and guide step-by-step learning. For example, an interactive whiteboard can show dynamic graphs, geometric transformations, or animated problem-solving processes. This makes lessons more engaging and helps students who struggle with traditional chalk-and-talk methods. Instructional technology ensures better clarity, accessibility, and retention of mathematical ideas.
- ii. **Computational and Productivity Tools:** These tools assist with complex calculations, graphing, and data analysis. Examples include graphing calculators, spreadsheet software (Excel), GeoGebra, MATLAB, Maple, and Wolfram Alpha. Students use these technologies to perform operations that would be tedious manually, such as plotting multiple graphs, solving simultaneous equations, or analyzing large datasets. By reducing the cognitive load associated with routine calculation, these tools free students to focus on understanding mathematical patterns, relationships, and concepts. They also support inquiry-based learning, where students can manipulate variables and instantly see the outcomes.
- iii. **Interactive and Exploratory Technology:** Interactive tools allow students to explore mathematical ideas through hands-on experimentation. Virtual manipulatives, dynamic geometry software (such as GeoGebra and Cabri), math simulations, and game-based learning platforms fall under this category. These technologies support constructivist learning, enabling students to discover concepts by manipulating shapes, testing hypotheses, and observing real-time feedback. For example, students can change the dimensions of a triangle in GeoGebra to explore how its area changes. This makes mathematics more intuitive and encourages problem-solving, reasoning, and creativity.
- iv. **Collaborative and Communication Technology:** This type of technology facilitates interaction and knowledge-sharing in mathematics learning. Examples include Google Classroom, Microsoft Teams, WhatsApp study groups, online discussion forums, and virtual classrooms. These tools support peer collaboration, group assignments, real-time problem-solving discussions, and teacher–student engagement outside the classroom. Through these platforms, students can share solutions, debate mathematical ideas, and work together on challenging tasks. Collaborative technology promotes

teamwork, communication skills, and enhanced understanding of mathematical concepts.

- v. **Assessment Technologies:** Assessment technologies provide automated or semi-automated ways of evaluating students' mathematical skills. Computer-Based Testing (CBT) platforms, adaptive assessment systems, online quizzes, digital test generators, and feedback applications all fall in this group. These tools offer immediate feedback, which is crucial for improving learning outcomes. They also help teachers identify students' strengths and weaknesses, track progress, and design tailored interventions. Assessment technologies address the limitations of traditional paper-based tests and make the evaluation process more efficient and data-driven.
- vi. **Learning Management Systems (LMS):** Learning Management Systems such as Moodle, Edmodo, Schoology, and Canvas integrate multiple educational functions into one platform. They allow teachers to upload lesson materials, assign homework, track performance, and communicate with students. In mathematics education, LMS platforms help teachers organize resources, structure learning activities, and monitor students' engagement. Students benefit from having all their mathematics lessons, assignments, and instructional videos in one place, making learning more flexible and continuous.
- vii. **Mobile Learning Technologies:** Mobile learning includes the use of smartphones, tablets, and educational apps for mathematics learning. Numerous apps provide tutorials, quizzes, step-by-step maths solutions, and interactive activities—examples include Photomath, Khan Academy, IXL, and Mathway. These tools support personalized learning, enabling students to study anytime, anywhere. They also support differentiated instruction by offering content geared toward various learning levels and styles. Mobile learning is particularly transformative in contexts where students lack access to computers.
- viii. **Virtual Reality (VR) and Augmented Reality (AR) Tools:** Emerging technologies such as VR and AR create immersive mathematics learning environments. AR apps can overlay shapes and graphs into the real world, helping students visualize geometry in three dimensions. VR can simulate mathematical environments where students walk through coordinate planes or interact with geometric models. These tools enhance spatial reasoning and deepen conceptual understanding, especially in topics such as geometry, trigonometry, and calculus. Examples of VR/AR tools are ENGAGE VR, Math VR, GeoGebra AR, Quiver, Merger Cube, Zspace, Google Expeditions.
- ix. **Artificial Intelligence (AI)-Based Tools:** AI-powered technologies are increasingly used in mathematics education to personalize learning. Tools such as adaptive learning platforms, intelligent tutoring systems, chatbots, and recommendation engines analyze students' performance and recommend tailored exercises. These technologies identify learning gaps and adjust the difficulty of tasks to match the student's ability. Examples of AI tools used in Mathematics Education are Photomath, Microsoft Math Solver, AI Chatbots, ChatGPT, Meta AI, Smartick, IXL, ASSISTments, ALEKS etc. AI tools help provide 24-hour mathematical support, making learning more efficient and individualized.
- x. **Digital Content Creation Tools:** These tools help students and teachers create and share mathematical content. Examples include Desmos, PowerPoint, Canva, and mathematical modeling software. Teachers use them to design instructional materials, while students use them to create presentations, visual explanations, and mathematical models. This strengthens students' digital literacy and deepens their understanding of mathematics through active knowledge creation.

The Influence of Technology Integration on Students' Engagement and Participation in Mathematics Classes

Technology integration significantly enhances students' engagement in mathematics classrooms by making abstract concepts more concrete, interactive, and relatable. Hegedus and Kaput (2017), opined that digital tools such as dynamic geometry software, graphing applications, and virtual manipulatives enable learners to visualize mathematical relationships in real time, thereby deepening understanding and sustaining attention. Similarly, O'Sullivan (2019) noted that technology fosters exploratory learning, allowing students to test hypotheses, receive immediate feedback, and correct misconceptions instantly. This responsiveness and interactivity promote active cognitive involvement, reducing mathematics anxiety and increasing motivation. When students interact with technology-rich environments, they experience mathematics in more meaningful and enjoyable ways, which improves their overall engagement.

Furthermore, technology integration improves students' participation by creating collaborative learning opportunities and supporting diverse learning styles. Fenyvesi et al.(2020), stated that digital platforms such as interactive whiteboards, learning management systems, and mathematics apps encourage peer discussions, shared problem-solving, and group-based exploration of mathematical tasks. These platforms also allow teachers to differentiate instruction, ensuring that both high- and low-achieving students participate meaningfully in class activities. Adu and Olatundun (2019) opined that technology-supported instruction empowers students to contribute actively, as it reduces the fear of failure by providing guided steps and immediate assistance. Overall, when technology is effectively embedded into mathematics pedagogy, it fosters a participatory environment where students are confident, collaborative, and more willing to engage in mathematical reasoning.

The Influence of Technology Integration on Students' Learning Outcomes in Mathematics.

Technology integration has been shown to significantly improve students' learning outcomes in mathematics by enhancing conceptual understanding, procedural fluency, and problem-solving skills. Clark-Wilson et al. (2014) opined that digital tools such as graphing calculators, computer algebra systems, and dynamic geometry software help students visualize complex mathematical ideas, which strengthens comprehension and supports deeper learning. Similarly, Li and Ma (2010) found that students exposed to technology-enhanced mathematics instruction performed better on standardized tests than those taught through traditional methods, indicating that technology can reinforce mastery of mathematical concepts. Interactive learning platforms also provide immediate feedback, allowing learners to self-correct and engage in continuous improvement, which contributes to improved academic performance. Additionally, technology supports differentiated instruction, ensuring that students with varying abilities achieve better learning outcomes. Adeyemi and Olayemi (2021) posited that technology-enabled instruction helps teachers tailor lessons to individual learning styles and paces, which minimizes learning gaps and promotes inclusivity in mathematics classrooms. Collaborative digital environments also foster peer learning; as noted by Zydney et al. (2020), virtual simulations and interactive tasks encourage students to work together, share strategies, and solve complex mathematical problems, leading to improved cognitive and social outcomes. Overall, the integration of technology not only enhances students' achievement but also builds confidence, autonomy, and engagement, all of which contribute to stronger learning outcomes in mathematics.

Identify the Challenges Teachers and Students Face in Integrating Technology into Mathematics Education in Public Secondary Schools

Teachers and students in public secondary schools face several challenges when integrating technology into mathematics education, many of which stem from infrastructural constraints and limited digital competence. Okafor and Eze (2020) asserted that inadequate access to technological tools such as computers, tablets, projectors, and stable internet connectivity continues to hinder effective implementation of technology-based instruction in many Nigerian public schools. Teachers also struggle with insufficient training and professional development; as Oyeniran and Omojola (2019) noted, many mathematics teachers lack the pedagogical and technical skills necessary to incorporate digital tools meaningfully into lessons. This results in low confidence, reluctance to adopt new tools, and reliance on traditional teaching methods. Furthermore, the absence of supportive policies, maintenance systems, and electricity supply undermines the sustainability of technology integration initiatives.

Students also face challenges related to digital literacy, accessibility, and distractions associated with technological devices. Yusuf and Balogun (2021) opined that many students in public secondary schools' lack adequate exposure to digital tools at home, making it difficult for them to engage effectively with technology-enhanced mathematics tasks. Limited access to personal devices and shared school computers also restricts hands-on learning opportunities. Additionally, when technology is available, students may become distracted by non-academic content or struggle to navigate digital learning platforms without guidance. Socioeconomic inequalities further widen the gap between students who can access technology outside school and those who cannot, leading to differences in performance and participation. As a result, despite its potential benefits, technology integration in mathematics education continues to face systemic and practical challenges that impede its full realization in public secondary schools.

Empirically, Mohammed et al. (2025) examined the role of digital technology in enhancing mathematics education in senior secondary schools in Lere Local Government Area of Kaduna State, Nigeria. The sample for the study comprised of 52 mathematics teachers drawn from the population of study using simple random sampling technique. The instruments for data collection in this study was a questionnaire and analyzed using mean and standard deviation via SPSS version 22. The results revealed that digital technology resources for teaching Mathematics in secondary schools within Lere LGA are largely unavailable, the extent of Mathematics teachers' utilization of digital technology in their instructional practices is generally low and teachers face significant challenges in integrating digital technology into Mathematics education.

Andrei (2025) examined the influence of technology integration on student engagement and learning outcomes within secondary education settings. Employing a mixed-methods research design, data were collected through surveys from a sample of 300 students and 20 teachers across five secondary schools in Ibadan, Nigeria. Quantitative analyses revealed a significant positive correlation between the use of interactive digital tools and increased student engagement levels. Furthermore, students exposed to technology-enhanced instruction demonstrated improved academic performance compared to those in traditional learning environments. Qualitative feedback from teachers highlighted enhanced student motivation and participation as key benefits of technology integration.

Okonkwo and Nwosu (2023) investigated the impact of blended learning (face-to-face + online resources) on students' conceptual understanding in algebra. Using a randomized controlled trial with 240 students across four schools, the researchers compared blended

instruction to traditional classroom teaching over eight weeks. Quantitative analysis (ANCOVA controlling for pretest scores) indicated substantial gains in conceptual understanding and retention for the blended-learning cohort. Qualitative interviews suggested that immediate feedback and interactive tasks increased students' engagement.

Yusuf and Balogun (2022) examined teachers' competence and readiness for ICT use in mathematics in a statewide survey. Using multistage sampling, 260 mathematics teachers completed a validated ICT competence inventory. Results indicated that while basic operational skills were common, pedagogical and evaluative uses of ICT were rare. Regression analyses linked years of continuous professional development and access to mentorship with higher competence scores, suggesting policy attention to sustained in-service programs.

Anihenya and Agah (2021) examined the impact of technology integration on student engagement and achievement in English and mathematics in Mubi South Local Government Area of Adamawa State. The study randomly sampled 250 SS II students from total population of 14,982 SS II in Mubi South LGA, Adamawa State. Data were collected through questionnaire and were analysed using mean, standard deviation as well as t-test analytical tool. It was found that students from highly technology integration schools had high level of academic engagement: significantly than those from less technology integration school. Students from highly technology integration schools had high level of academic achievement significantly than those from less technology integration school.

Adetunji and Owolabi (2020) evaluated interactive instructional software's effect on algebra retention using a Solomon four-group design to control for pretest sensitization. The large-sample experimental study found that students exposed to interactive software had higher immediate and delayed retention scores compared to non-software groups. The results were robust across gender and socio-economic subgroups, suggesting potential equity gains from well-designed software interventions.

Anene and Okonkwo (2019) used a quasi-experimental design to assess multimedia instruction's impact on students' interest and comprehension in trigonometry. Through pretest–posttest comparisons and student attitude questionnaires, the study reported significant increases in both comprehension scores and self-reported interest for the multimedia cohort. Qualitative feedback highlighted that animations and step-wise problem demonstrations reduced mathematics anxiety.

Afolabi (2019) conducted a cross-sectional survey of ICT availability and teacher usage patterns in mathematics classrooms across three Nigerian states. Using questionnaires administered to 300 mathematics teachers and classroom observations, the study found that although some schools had basic ICT equipment, actual pedagogical integration was low—devices were often used for administrative tasks rather than instructional activities. Regression analysis indicated that teacher ICT competence and school leadership support were significant predictors of classroom ICT use.

Akinsola (2018) aimed to evaluate the effect of computer-assisted instruction (CAI) on secondary school students' achievement in mathematics. The study employed a quasi-experimental design involving two intact classes (treatment and control) in urban Nigerian schools. Pre- and post-tests were administered and analyzed using t-tests. Results showed that students exposed to CAI scored significantly higher on post-test measures of procedural fluency and problem solving compared to the control group taught via conventional methods.

The author concluded that CAI can improve mathematics achievement when appropriately integrated into instruction.

Tella et al. (2017) focused on teacher attitudes and how these mediate ICT adoptions in mathematics instruction. The study surveyed 220 mathematics teachers using validated scales for attitude, perceived usefulness, and self-efficacy, and employed structural equation modeling (SEM). Findings showed that positive attitudes and high self-efficacy significantly predicted perceived usefulness and actual ICT use in class. The authors emphasized the role of teacher beliefs and recommended attitude-focused professional development.

Conclusion

It was concluded that technology integration positively influences students' learning and engagement in public secondary schools. Technology integration significantly enhances students' learning outcomes in mathematics: Tools such as dynamic geometry software, graphing calculators, simulations, and interactive apps improve students' conceptual understanding and problem-solving skills. Students' engagement and participation increase when technology is used effectively: Digital tools make lessons more interactive, stimulating students' interest, attention, and willingness to participate in classroom activities. Mathematics teachers who receive proper ICT training demonstrate stronger competence in integrating technology: Professional development improves teachers' confidence, skill levels, and readiness to incorporate digital resources into instruction. Inadequate infrastructure remains a major barrier to effective technology integration: Schools struggle with poor electricity, insufficient computers, unstable internet connectivity, and outdated digital devices. Students in schools with consistent access to digital tools show better academic performance compared to those in low-technology environments: Regular exposure to ICT enhances practice, self-paced learning, and retention. Mathematics lessons supported with multimedia resources reduce anxiety and increase students' motivation and engagement

Suggestions

Drawing from the reviewed literature of this work, the following suggestions were proffered:

- i. School administrators and mathematics teachers should adopt interactive technological tools to promote active student participation and engagement during mathematics lessons.
- ii. Government and education stakeholders should provide adequate technological facilities, such as computers, projectors, and reliable internet access, in all public secondary schools.
- iii. To overcome the barriers to technology integration, education policymakers should implement supportive ICT policies, ensure steady power supply in schools, and establish maintenance and technical support units.
- iv. Policies should focus on reducing the urban–rural divide by providing students in rural and underserved schools with access to digital devices, learning management systems, and online educational platforms to ensure inclusivity.
- v. Education policymakers should provide technical support units within schools to maintain technological equipment, troubleshoot problems, and ensure uninterrupted use of digital tools for mathematics instruction.

REFERENCES

- Adebayo, O. A. (2020). Impact of information and communication technology on students' achievement in mathematics in Nigerian secondary schools. *International Journal of Educational Technology and Learning*, 9(2), 67–75.
- Adetunji, A. A., & Owolabi, T. (2020). Interactive instructional software and students' retention in algebra: A Solomon four-group study. *Journal of Educational Technology*, 15(2), 45–56.
- Adeyemi, B. A., & Olayemi, O. S. (2021). Technology integration and learning outcomes in secondary school mathematics in Nigeria. *African Journal of Educational Technology*, 6(2), 45–58.
- Adu, E. O., & Olatundun, S. O. (2019). Technology integration and students' classroom participation in mathematics: Implications for innovative teaching. *Journal of Education and Practice*, 10(4), 45–53.
- Afolabi, F. (2019). Teachers' use of information and communication technologies in secondary school mathematics teaching in Nigeria. *African Journal of Educational Research*, 23(1), 88–102.
- Akinsola, M. K. (2018). Computer-assisted instruction in mathematics: Effects on students' performance in Nigeria. *African Journal of Educational Studies in Mathematics and Sciences*, 14(1), 33–48.
- Andrei, M. (2025). The impact of technology integration on student engagement and learning outcomes in secondary education. *Journal of Educational Technology and Curriculum Development*, 14(4), 111–133.
- Anene, C. J., & Okonkwo, P. O. (2019). Multimedia integration and students' interest in mathematics learning. *Nigerian Journal of Science and Technical Education*, 5(2), 21–35.
- Anihenya, J., & Agah, M. (2021). The impact of technology integration to students engagement and achievement in English and Mathematics in MUBI South Local Government, Adamawa State. *Asian Journal of Social Science and Management Technology*, 3(3), 25 – 35.
- Charles-Ogan, G.I. (2016). Practical utility of Mathematics concepts among senior secondary school students in Rivers State, <https://www.idpublications.org>
- Clark-Wilson, A., Robutti, O., & Sinclair, N. (2014). *The mathematics teacher in the digital era: An international perspective*. Springer.
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340.
- Eze, P. N. (2022). Barriers to effective technology integration in mathematics classrooms of Nigerian public schools. *Nigerian Journal of Educational Research and Evaluation*, 21(1), 102–114.

- Fenyvesi, K., Kauppinen, M., & Lavicza, Z. (2020). Enhancing student participation in mathematics through digital tools. *International Journal of STEM Education*, 7(1), 1–12.
- Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2014). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1), 59–109.
- George, N. R., & Charles-Ogan, G. I. (2023). *Essentials of Mathematics instruction*. Katapuno Press
- George, N.R., & Zalmon, I. G. (2019). Innovative instructional strategies and senior secondary students' achievement in algebra. *European Journal of Education Studies*, 6(9), 193- 209.
- Hegedus, S. J., & Kaput, J. (2017). Interactivity and mathematical learning in technology-rich classrooms. *Educational Studies in Mathematics*, 96(2), 253–272.
- Li, Q., & Ma, X. (2010). A meta-analysis of the effects of computer technology on school students' mathematics learning. *Educational Psychology Review*, 22(3), 215–243.
- Mohammed, A. S., Jatto O. F., and Shuaibu, S. (2025). The role of digital technology in enhancing mathematics education in senior secondary schools in Lere Local Government Area of Kaduna State. *African Journal of Humanities & Contemporary Education Research*, 18(1), 250 – 259.
- Odili, G.A. (2006). *Mathematics in Nigerian secondary schools: A teaching perspective*. Rex Charles & Patrick Ltd.
- Okafor, C. T., & Eze, G. A. (2020). Challenges of technology integration in mathematics teaching in Nigerian public schools. *Nigerian Journal of Educational Technology*, 5(1), 23–34.
- Okafor, C. N., & Olatunji, A. A. (2023). Digital divide and its impact on students' participation in ICT-based mathematics instruction. *Nigerian Journal of Educational Development Studies*, 9(1), 45–59.
- Okojie, M. C., Olinzock, A. A., & Okojie-Boulder, T. C. (2020). The pedagogy of technology integration in mathematics instruction. *International Journal of Education and Development Using ICT*, 16(2), 45–59.
- Okonkwo, C. I., & Nwosu, V. C. (2023). Blended learning and conceptual understanding in secondary school algebra in Nigeria. *Journal of Educational Technology & Practice*, 9(3), 89–102.
- Olojede, O. A., & Adeoye, F. O. (2021). Integrating ICT tools in mathematics teaching and its effect on students' learning outcomes in Nigerian secondary schools. *Nigerian Journal of Educational Research*, 17(3), 98–112.
- O'Sullivan, M. (2019). Digital technology and student engagement in secondary school mathematics. *Mathematics Education Review*, 31(2), 18–32.

- Oyeniran, O. R., & Omojola, O. (2019). Teachers' readiness and barriers to ICT use in secondary school mathematics classrooms. *African Journal of Teacher Education*, 8(2), 112–129.
- Roblyer, M. D., & Doering, A. H. (2019). *Integrating educational technology into teaching* (8th ed.). Pearson Education.
- Tella, A., Tella, A., & Adedeji, S. O. (2017). Teachers' attitudes, self-efficacy and ICT adoption in mathematics instruction. *Nigerian Journal of Educational Technology*, 7(2), 95–109.
- Trowler, V. (2020). *Student engagement literature review*. The Higher Education Academy.
- Yusuf, M. O., & Balogun, M. R. (2021). Digital literacy and students' preparedness for technology-supported learning in public secondary schools. *Journal of e-Learning and Educational Technology*, 12(3), 45–58.
- Yusuf, M. O., & Balogun, A. D. (2022). Teachers' competence and readiness for technology integration in mathematics education in Nigerian secondary schools. *African Journal of Educational Technology*, 8(2), 27–36.
- Zydney, J. M., Warner, Z., & Angelone, L. (2020). *Learning through collaborative digital environments in mathematics education*. *Journal of Computer Assisted Learning*, 36(1), 45–58.