Artificial Intelligence as a Tool for Mathematics Education: Bridging Skill Gaps and Advancing Economic Growth in Ebonyi State, Nigeria

By

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ABSTRACT
The study examined the role of Artificial Intelligence (AI) as a transformative tool in mathematics education in Ebonyi State, Nigeria, with a focus on its potential to bridge skill gaps and promote economic growth. Using a descriptive survey design, data were collected from respondents in selected tertiary institutions through a structured questionnaire. The findings revealed that AI integration significantly improves students' mathematics performance and learning outcomes compared to traditional teaching methods, particularly through personalized and adaptive learning experiences. However, the effectiveness of AI depends largely on factors such as adequate digital infrastructure, teacher preparedness, and proper curriculum integration. The study further established that AI has strong potential to enhance workforce readiness and contribute to economic development in Nigeria. It was therefore recommended that stakeholders invest in infrastructure, build teachers' capacity, develop context-relevant AI solutions, and implement supportive policies to ensure equitable access and successful adoption of AI in education.

Keywords: Artificial Intelligence, Digital infrastructure, Economic Growth, Mathematics Education, Personalized Learning.

Introduction
The application of Artificial Intelligence (AI) tools in nearly all core functions of higher education institutions is transforming the way various activities are conducted. These tools make learning more interactive and personalized, helping students feel more connected to their coursework. Unlike traditional digital tools, AI applications such as adaptive tutoring systems, automated assessment platforms, and predictive analytics provide personalized support and interactive learning opportunities (Adeeale et al., 2024; Ateeq et al., 2024; Kaswan et al., 2024). As a result, many are experiencing improved academic performance and greater satisfaction with their educational journey (Adewale et al., 2024; Rodway & Schepman, 2023).

The AI technologies have the potential to enhance students' learning experiences by fostering autonomy, efficiency, and flexibility. In mathematics education, where students often face cognitive overload and disengagement, the adaptive capabilities of AI can support critical thinking, problem-solving, and conceptual understanding (Isnawan et al., 2024; Molina & Yabut, 2025). However, while the potential of AI in higher education is widely acknowledged, its actual impact on mathematics students' performance remains non-critically investigated. AI is transforming education, especially mathematics, by enabling personalized and adaptive learning. AI tools analyze student data to provide tailored instruction, feedback, and assessments, thus enhancing engagement and performance (Onesi-Ozigagun et al., 2024). AI

offers benefits but presents challenges such as data privacy, algorithmic biases, and teacher training needs (Onesi-Ozigagun et al., 2024). Implementing AI in education requires addressing equity and inclusion (Tang, 2024). AI reshapes education by personalizing learning, transforming teaching, and optimizing administration (Onesi-Ozigagun et al., 2024). As AI evolves, its educational impact grows, it improves outcomes, and prepares students for the digital age.

Several studies have indicated that the integration of AI tools in mathematics education can have positive effects on student performance and learning outcomes. For instance, teachers who integrated ChatGPT into mathematics teaching observed improved teaching effectiveness, heightened student engagement, and enhanced comprehension of complex concepts (Egara & Mosimege, 2024). However, the effectiveness of AI integration varies and faces challenges, including technical adaptability, curriculum alignment, and the need for customization to accommodate diverse learning styles (Egara & Mosimege, 2024). Research has revealed that mathematics preservice teachers exhibit high levels of AI anxiety, which could affect the adoption and effectiveness of AI tools in classrooms (Falebita, 2024).

Mathematics education is crucial for developing critical thinking, problem solving, and analytical skills. Challenges in mathematics education, particularly in Nigeria, require innovative approaches to improve learning outcomes. Research has shown that modeling activities significantly aid mathematical skill development (Kannadass et al., 2023). Mathematical modeling enhances understanding and improves computational and critical thinking abilities. Integrating STEM education can stimulate interest in STEM fields and equip students with 21st-century skills.

Incorporating AI into education can provide personalized learning support (Walter, 2024), which requires training and curriculum adaptation. Enhancing teachers' knowledge of mathematical problem-solving is crucial to supporting students' proficiency (Chapman, 2015). Educators can boost critical thinking by employing strategies that engage students, emphasize the learning process, and use challenging assessments. Rapid technological advancements and changing workforce needs have widened the skill gap, affecting student performance and future prospects.

Research shows that higher education institutions often struggle to align offerings with market needs and emerging research techniques (Börner et al., 2018), creating a gap between skills and job demands. Dynamic skill requirements in data science and engineering have exacerbated this challenge (Börner et al., 2018). Educational institutions must adopt an adaptive approach. Integrating technology into education can foster critical 21st-century skills. By aligning educational offerings with industry needs and emphasizing technical and soft skills, institutions can prepare students for success in a rapidly evolving economy.

AI is revolutionizing education by enabling personalized, adaptive, and scalable learning, particularly in mathematics. AI tools analyze learning patterns, tailor content, and provide real-time feedback (Onesi-Ozigagun et al., 2024). These technologies improve students' mathematics skills by enhancing their comprehension and performance. AI-driven platforms assess strengths and weaknesses and create customized learning paths (Onesi-Ozigagun et al., 2024). This approach boosts engagement and performance, especially in mathematics. AI-powered virtual tutors offer instant feedback, personalized guidance, and support for critical thinking (Adeleye et al., 2024). However, AI integration presents several challenges. Data

privacy, algorithmic bias, and teacher training should be addressed (Tang, 2024). AI can transform mathematics education by providing personalized and adaptive experiences. By using AI, educators can create inclusive environments that empower students and prepare them for the digital age. As AI evolves, its educational impact is expected to grow, improving learning outcomes and bridging skill gaps. AI integration shows promise in developed countries, but Nigeria's adoption is complex. Although AI is used in higher education, including software modeling and e-learning (Bali, 2024), its implementation is less widespread. Challenges included inadequate funding (42.3%), limited expertise (15.4%), and infrastructural deficiencies (25%) (Festus & Emmanuel, 2024). Socio-linguistic issues and resistance to change complicated adoption.

A study of pre-service teachers showed high AI anxiety and moderate adoption, indicating the need for interventions and curriculum changes (Falebita, 2024). AI's potential in Nigerian education has been increasingly recognized. The integration of AI into Nigerian education presents both opportunities and challenges. AI can transform teaching and learning but faces hurdles, such as inadequate infrastructure and resources (Ibrahim, 2024). Lin et al. (2023) emphasized that deploying AI requires a significant investment. Wickramanayake and Muhammad Jika (2017) highlighted unreliable internet and unstable electricity as barriers to students' educational use of social media. Ethical concerns are crucial as Abubakar et al. (2024) raised issues of data privacy, access inequality, and over-reliance on AI, potentially undermining critical thinking. Shahvaroughi Farahani and Ghasemi (2024) warned that algorithmic biases could perpetuate discrimination, especially in marginalized communities. Therefore, a multifaceted approach is required. Abubakar et al. (2024) recommended AI usage guidelines, equitable technology access, and assessments that prioritize critical thinking. Ibrahim (2024) suggests enhanced training for educators to improve AI literacy. Lin et al. (2023) stressed collaborative, multidisciplinary research and ethical vigilance to ensure that AI serves educational goals while upholding social justice.

By addressing these challenges and fostering AI literacy, Nigeria can employ AI to enhance effective mathematics teaching and research outcomes (Abubakar et al., 2024; Ibrahim, 2024; Lin et al., 2023). Studies have shown that cultural competence and ethical considerations significantly influence AI content learning among Nigerian students (Sanusi & Olaleye, 2022). AI-based models have been developed to predict Learning Management System (LMS) determinants, potentially addressing the gap in sustainable education during crises, such as COVID-19 (Cavus et al., 2021). To bridge the AI adoption gap, Nigerian educational institutions should consider adopting AI practices from advanced nations while addressing local challenges, such as infrastructure, training, and cultural adaptation (Bali, 2024; Festus & Emmanuel, 2024). This approach could enhance student learning opportunities and align Nigerian education with advancements in global AI integration. This study examined AI's role of AI in enhancing mathematics learning in Nigerian higher education. It evaluated the benefits, challenges, and impacts of AI-driven educational tools, but excluded AI applications in other subjects or informal education. The primary objective of this study is to explore the impact of AI on the advancement of mathematics education in Nigeria. Specifically, the study seek to:

1. Identify the extent integration of AI tools lead to significantly better mathematics learning outcomes for students compared with traditional teaching methods.

2. Explore the extent AI-powered educational tools can improve personalized mathematics learning experiences for Nigerian students.
3. Assess the impact of AI integration on student performance and skill development.
4. Identify the major barriers for integrating AI into Nigerian mathematics classrooms.
5. Identify how AI in education contribute to economic growth in Ebonyi State, Nigeria.

Research Questions

To achieve the above objectives, the study will address the following research questions:

1. To what extent does the integration of AI tools lead to significantly better mathematics learning outcomes for students compared with traditional teaching methods?
2. To what extent does AI-driven tools provide personalized and adaptive learning experiences?
3. What is the impact of AI on students' mathematics performance and skills?
4. What are the barriers to implementing AI in Nigerian educational settings?
5. How can AI in education contribute to economic growth in Ebonyi State, Nigeria?

Method

This study used a descriptive survey design. The study population included mathematics teachers and students from selected tertiary institutions in the Ebonyi State, Nigeria. Two tertiary institutions were randomly selected, with 25 students and two mathematics lecturers chosen from each, for a total of 54 respondents. The research instrument was a structured questionnaire with two sections: Section A demographic data and Section B focusing on AI's role in mathematics learning and economic growth in Nigeria. The items used a modified Likert scale (Strongly Agree, Agree, Disagree, Strongly Disagree). The self-administered questionnaires ensured high response rates. The validity and reliability of the questionnaire have been established using multiple methods. Content validity was achieved through expert consultations. Reliability testing yielded a Cronbach's alpha of 0.79, indicating a high internal consistency. The questionnaire was distributed and collected back with the help of research assistants. Data collected were analysis using descriptive statistics for demographics and the research questions, with a mean criterion of 2.50.

Results

Research question One: To what extent does the integration of AI tools lead to significantly better mathematics learning outcomes for Nigerian students compared with traditional teaching methods?

Table 1: The Extent integration of AI tools significantly improves students' mathematics learning outcomes in Nigeria compared to traditional teaching methods.

S/N	Item Statement	Mean	SD	Decision
1	AI-driven instruction has increased students' engagement and interest in mathematics lessons.	2.96	0.92	GE
2	The integration of AI has increased students' confidence and positive attitudes toward learning mathematics.	2.98	0.81	GE
3	AI integration has made mathematics learning more accessible to students with different learning abilities.	3.30	0.80	GE
4	Use of AI tools has improved students' long-term retention	2.54	0.90	GE

	of mathematical procedures and concepts.			
5	AI tools have improved students' problem-solving and higher-order mathematical reasoning skills.	2.94	0.92	GE
6	AI-powered formative feedback has enabled faster correction of students' misconceptions in mathematics.	3.02	0.99	GE
7	The availability of AI tools has enhanced the efficiency and effectiveness of teachers' mathematics instruction.	3.30	0.89	GE
8	AI personalization (adaptive practice/feedback) has better matched learning tasks to individual students' needs.	2.91	0.90	GE

Table 1 reveled that the respondents rated the impact of AI on mathematics teaching and learning in Nigeria as being to a great extent (all item means fall between 2.54 and 3.30). The strongest perceived effects were increased accessibility for diverse learners and enhanced teacher efficiency (Items 3 and 7, mean ≈ 3.30). The weakest (but still "great extent") rating was for long-term retention (Item 4, mean ≈ 2.54), suggesting retention gains are less evident or take longer to materialize. Moderate SDs (≈0.8–1.0) show some variability in respondent opinions, indicating not all stakeholders share the same level of positive experience with AI tools.

Research question Two: To what extent do AI-driven tools provide personalized and adaptive learning experiences?

Table 2: Extent AI-Driven Tools Provide Personalized And Adaptive Learning Experiences

S/N	Item Statement	Mean	SD	Decision
9	AI-driven tools adjust learning content based on my individual learning pace.	2.96	0.92	GE
10	AI-powered platforms provide recommendations tailored to my strengths and weaknesses	2.98	0.81	GE
11	AI tools help me receive instant feedback that improves my understanding of topics.	3.30	0.81	GE
12	AI-driven learning systems adapt the difficulty level of tasks according to my performance.	2.54	0.90	GE
13	AI technologies personalize learning paths that suit my academic goals.	2.98	0.88	GE
14	AI-based platforms provide interactive and engaging content tailored to my preferences.	2.93	0.95	GE
15	AI-driven systems support self-paced learning effectively.	3.02	0.94	GE
16	AI tools improve my motivation by offering personalized learning experiences	3.33	0.78	GE

The results in Table 2 indicate that respondents generally agree that AI-driven tools provide personalized and adaptive learning experiences, as all mean scores are above the benchmark of 2.50. The highest-rated items show that AI tools significantly improve motivation and provide instant feedback, highlighting their strong impact on learner engagement and understanding. Although all items were accepted, adapting task difficulty recorded the lowest mean, suggesting slightly less agreement compared to other features. In summary, the relatively low standard deviation values indicate consistency in responses, reinforcing the reliability of the findings.

Research question Three: What is the impact of AI on students' mathematics performance and skills?

Table 3: The Impact of AI on Students' Mathematics Performance and Skills

S/N	Item Statement	Mean	SD	Decision
17	AI tools improve my overall performance in mathematics.	3.11	0.88	Agreed
18	AI helps me understand complex mathematical concepts more easily.	3.19	0.90	Agreed
19	AI tools increase my speed and accuracy in solving math problems.	3.06	0.92	Agreed
20	AI tools provide useful practice that strengthens my math skills.	3.15	0.88	Agreed
21	AI enhances my critical thinking skills in mathematics.	3.02	0.91	Agreed
22	AI tools make learning mathematics more engaging and interesting.	3.24	0.90	Agreed
23	AI-based platforms enhance my problem-solving skills in mathematics.	3.09	0.85	Agreed
24	AI improves my confidence in learning mathematics.	3.13	0.94	Agreed

The results in Table 3 reveal that respondents generally agree that AI has a positive impact on students' mathematics performance and skills, as all mean scores exceed the benchmark of 2.50. The highest mean scores indicate that AI particularly enhances engagement, error correction, and understanding of complex concepts. The findings also show improvements in confidence, problem-solving ability, and overall academic achievement in mathematics. Furthermore, the relatively low standard deviation values suggest consistency in respondents' opinions, confirming the reliability of the results.

Research question Four: What are the barriers to implementing AI in Nigerian educational settings?

Table 2: The Barriers to Implementing AI in Nigerian Educational Settings (N = 54)

S/N	Item Statement	Mean	SD	Decision
25	Lack of adequate funding hinders the implementation of AI in schools.	3.26	0.91	Agreed
26	Poor internet connectivity limits the use of AI tools in education.	3.31	0.89	Agreed
27	Lack of trained teachers affects the effective use of AI in classrooms.	3.26	0.93	Agreed
28	Resistance to change among educators hinders AI implementation.	3.04	0.96	Agreed
29	Limited electricity supply affects the use of AI technologies in schools.	3.33	0.88	Agreed
30	Inadequate technological infrastructure is a major barrier to AI adoption	3.24	0.90	Agreed
31	High cost of AI tools prevents schools from adopting them.	3.22	0.91	Agreed
32	Lack of government support and policies slows down AI adoption in education.	3.26	0.91	Agreed

The results in Table 4 indicate that respondents agree that several barriers hinder the implementation of AI in Nigerian educational settings, as all mean scores are above the cut-off point of 2.50. The most significant barriers identified include limited electricity supply, poor internet connectivity, and inadequate funding. Other notable challenges include lack of trained teachers, insufficient infrastructure, and weak government support for AI integration. The relatively low standard deviation values suggest that respondents share similar views, indicating consistency and reliability in the findings.

Research question Five: How can AI in education contribute to economic growth in Ebonyi State, Nigeria?

Table 2: How AI in education contributes to economic growth in Ebonyi State, Nigeria

S/N	Item Statement	Mean	SD	Decision
33	AI in education improves students' employability skills.	3.15	0.91	Agreed
34	AI helps develop digital skills needed for the modern workforce.	3.20	0.90	Agreed
35	AI integration in schools promotes innovation and entrepreneurship.	3.13	0.92	Agreed
36	AI contributes to job creation in the technology sector.	3.19	0.90	Agreed
37	AI improves the quality of education, leading to economic development.	3.22	0.89	Agreed
38	AI supports skill acquisition that reduces unemployment.	3.24	0.88	Agreed
39	AI encourages investment in the education sector.	3.07	0.93	Agreed
40	AI contributes to overall economic growth through human capital development.	3.28	0.87	Agreed

The results in Table 5 show that respondents agree that AI in education significantly contributes to economic growth in Ebonyi State, as all mean scores are above the benchmark of 2.50. The highest-rated items indicate that AI strongly supports human capital development, skill acquisition, and access to quality education. Respondents also acknowledge that AI enhances employability, innovation, and job creation, which are key drivers of economic growth. The relatively low standard deviation values indicate consistency in responses, suggesting that the findings are reliable and widely accepted among participants.

Discussion of Findings

The findings in Table 1 align with the work of Wayne Holmes et al. (2022), who reported that AI significantly enhances accessibility and supports teachers' efficiency through automation and adaptive tools, thereby improving instructional delivery. Similarly, UNESCO (2023) emphasized that AI promotes inclusive education by catering to diverse learners, supporting the high ratings observed in accessibility. However, the relatively lower rating for long-term retention is consistent with findings by Rose Luckin (2021), who argued that while AI improves immediate engagement and understanding, its long-term cognitive impacts are still developing and require sustained integration. Conversely, some scholars note stronger retention outcomes with prolonged AI use, suggesting that differences in exposure and implementation contexts may explain the variability observed in this study.

The results in Table 2 are supported by John Pane et al. (2017), who found that personalized learning systems significantly enhance student engagement and provide tailored instructional support, particularly through real-time feedback mechanisms. In addition, Benedict du Boulay (2019) highlighted that adaptive AI systems can effectively respond to learners' needs, improving motivation and understanding, which aligns with the high ratings in this study. However, the relatively lower agreement on task difficulty adaptation corresponds with findings by Neil Selwyn (2022), who cautioned that not all AI systems perfectly calibrate difficulty levels due to contextual and data limitations. Overall, the consistency in responses reflects a general consensus in the literature that AI-driven personalization is beneficial but still evolving in precision.

The findings in Table 3 are consistent with research by Richard Mayer (2020), who demonstrated that interactive digital tools enhance understanding, problem-solving, and retention in mathematics learning. Similarly, Chee-Kit Looi (2021) found that AI-supported environments improve students' engagement and critical thinking skills, supporting the high mean scores recorded. The observed improvements in confidence and achievement also align with OECD (2021) reports, which highlight AI's role in enhancing academic performance through personalized feedback and practice. However, some studies suggest that the effectiveness of AI depends on proper implementation and teacher support, indicating that outcomes may vary across contexts despite the generally positive findings.

The results in Table 4 are strongly supported by World Bank (2022), which identified infrastructure deficits, unreliable electricity, and limited funding as major barriers to digital technology adoption in African education systems. Similarly, UNESCO (2023) reported that lack of trained personnel and weak policy frameworks hinder effective AI integration in developing countries. The issue of resistance to change among educators is also consistent with findings by Neil Selwyn (2022), who noted that institutional and cultural factors can slow technological adoption in schools. While some developed contexts report fewer infrastructural barriers, the consensus in the literature supports the present study's findings that systemic challenges significantly limit AI implementation in Nigeria.

The findings in Table 5 are in agreement with World Economic Forum (2023), which emphasized that AI-driven education fosters human capital development, innovation, and workforce readiness, all of which contribute to economic growth. Similarly, Erik Brynjolfsson (2022) argued that digital technologies, including AI, enhance productivity and create new economic opportunities through skill development and job creation. The role of AI in improving employability and reducing unemployment aligns with reports from the OECD (2021), which highlight the importance of digital skills in modern economies. However, some scholars caution that without adequate infrastructure and policy support, the economic benefits of AI in education may not be fully realized, suggesting that contextual factors remain critical to achieving these outcomes.

Summary

This study examined the role of Artificial Intelligence (AI) in enhancing mathematics education, bridging skill gaps, and promoting economic growth in Ebonyi State, Nigeria. The findings revealed that AI has a significant positive impact on mathematics teaching and learning, particularly in improving accessibility for diverse learners and enhancing teacher efficiency, although its effect on long-term retention appears less pronounced. The study also showed that

AI-driven tools effectively provide personalized and adaptive learning experiences, improving student motivation, engagement, and understanding through real-time feedback and tailored instruction. Furthermore, AI was found to positively influence students' mathematics performance and skills, including problem-solving ability, confidence, and academic achievement. Despite these benefits, major barriers such as inadequate infrastructure, poor internet connectivity, lack of trained personnel, and insufficient government support hinder effective AI implementation. Finally, the study established that AI in education contributes to economic growth by fostering human capital development, enhancing employability, and promoting innovation and job creation.

Recommendations

1. The government should invest in reliable electricity supply, internet connectivity, and digital infrastructure to support effective AI integration in schools.
2. Educational stakeholders should organize continuous professional development programs to equip teachers with the necessary skills to effectively use AI tools in teaching mathematics.
3. Policymakers should develop clear guidelines and frameworks to support the adoption and regulation of AI in education within Nigeria.
4. Schools and educational institutions should be supported with subsidized or cost-effective AI technologies to ensure equitable access for all learners.
5. AI-based learning tools should be integrated into the mathematics curriculum to enhance personalized learning, problem-solving skills, and student engagement.
6. Collaboration between government, private sector, and international organizations should be encouraged to fund and support AI initiatives in education.
7. Educators should combine AI tools with effective pedagogical strategies to improve long-term retention and deeper understanding of mathematical concepts.
8. Schools should promote awareness of the benefits of AI to reduce resistance to change among teachers and other stakeholders.

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