

REVOLUTIONIZING MATHEMATICS EDUCATION: LEVERAGING ARTIFICIAL INTELLIGENCE, INNOVATION AND CREATIVITY IN NIGERIA SECONDARY SCHOOL SYSTEM

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Abstract

Advances in Artificial Intelligence (AI) present significant opportunities to transform mathematics education in Nigeria's secondary school system. This paper interrogates how AI can be leveraged, in concert with innovation and creativity, to address longstanding challenges in mathematics teaching and learning. Drawing on a review of literature, policy documents and recent empirical studies in Nigeria, the article explores definitions of key concepts, gives historical background, examines the extent of AI penetration in Nigerian secondary schools, discusses the implications of AI deployment and highlights the roles of innovation and creativity. Findings indicate that while AI holds promise for personalized learning, immersive assessment and teacher support, barriers such as inadequate infrastructure, teacher preparedness, policy gaps, cost and equity persist. The paper concludes with recommendations for policy, practice and further research to better integrate AI, stimulate innovation and foster creativity so that mathematics education can more effectively serve Nigeria's youth and national development goals.

Keywords: Mathematics Education, Artificial Intelligence, Innovation and Creativity.

Introduction

Mathematics is foundational to scientific, technological, economic and social development. It underpins STEM fields, supports problem-solving, critical thinking and analytical reasoning. Yet in Nigeria, secondary school mathematics education has faced persistent challenges such as: low achievement, mathematics anxiety, large class sizes, unequal access to quality resources, outdated pedagogies and limited teachers' professional development. These challenges have inhibited student performance in external and internal examinations (Lesson, 2024 and WAEC. 2024) and constrained the ability of many learners to engage meaningfully with further education or technology-oriented careers. Simultaneously, developments in Artificial Intelligence (AI) are reshaping many sectors globally, including education. AI offers possibilities for adaptive, personalized learning; automated assessment; intelligent tutoring; analytics to identify students' weaknesses; and virtual learning environments. When paired with innovation (novel methods, tools, approaches) and creativity (originality, divergent thinking, new ways of solving problems), AI has the potential to revolutionize mathematics education.

This article investigates how AI, innovation, and creativity can be leveraged within the Nigerian secondary school system to enhance mathematics education. This paper seeks to: Define key concepts (AI, innovation, creativity) in the context of mathematics education. Provide a historical background of mathematics education in

Nigeria. Examine the current state of AI penetration in Nigerian secondary schools and related empirical findings. Analyse the implications of integrating AI into mathematics education. Explore the roles and integration of innovation and creativity alongside AI. Summarize findings, make recommendations and conclude with potential directions.

Conceptual Definition of Terms

For clarity, the following definitions are offered:

Mathematics Education: The process and practice of teaching and learning mathematics, especially at the secondary school level; includes curriculum design, classroom pedagogy, assessment, teacher preparation and resource provision.

Artificial Intelligence (AI): Systems or tools that perform tasks which normally require human intelligence, including but not limited to adaptive learning, natural language processing (e.g., chatbots), intelligent tutoring, predictive analytics and automated assessment (Robinson, 2018; Ighalo, Blaney and Sachdeva, 2018).

Innovation: The introduction and implementation of new methods, tools, curricula, or pedagogies in mathematics teaching and learning to improve outcomes. Innovation might involve novel technologies, reformed teaching strategies or new assessment models.

Creativity: The capacity for original thought, divergent thinking, problem posing and solving in mathematics; enabling students (and teachers) to generate non-routine solutions, explore multiple approaches and see mathematics not only as rote computation but as exploration and invention.

Secondary School System (Nigeria): The formal educational level following primary education, typically comprising Junior Secondary School (JSS1-3) and Senior Secondary School (SSS1-3), under the Nigerian 6-3-3-4 system (or its evolving modifications of 9-3-4), governed by Federal and State Ministries of Education.

Historical Background

Tracing the development of mathematics education in Nigeria reveals several phases:

Colonial and Early Post-Colonial Era: Mathematics was introduced under colonial educational systems largely through British models, emphasizing arithmetic, geometry, algebra, often in abstract form with heavy reliance on lecture-driven teaching and memorization. Teacher training was limited; resources and facilities were often concentrated in urban centers (Kirusuf, 2024).

Expansion and Reform (1970s-1990s): After independence, education expanded; more secondary schools were established; curricula were modified through agencies such as the Nigerian Educational Research and Development Council (NERDC, 2024). However, many issues persisted: shortage of qualified mathematics teachers, insufficient laboratories or teaching aids, large class sizes and limited use of technology.

Globalization and ICT Integration (2000s-2010s): With the proliferation of Information and Communications Technology (ICT), Nigeria began integrating computers, projectors and digital tools into education. Yet challenges of electricity, internet connectivity, cost, teacher skill remained. Mathematics instruction remained

largely traditional in many secondary schools (Ibhaluobe and Benjamin , 2021; Geoff, 2001).

Recent Shifts toward Innovative Pedagogies and AI Awareness: In the last 5-10 years, scholarship has grown on innovation (e.g. productive pedagogies, active learning, collaborative classrooms), creativity (e.g. hands-on mathematics labs) and nascent work integrating AI or digital learning platforms (including research on chatbots, AI-based assessment and adaptive software) into mathematics education (Robinson, 2018). However, large-scale, systemic adoption remains limited.

AI Penetration in Secondary Schools in Nigeria

Empirical studies and policy analyses provide insight into how far AI has penetrated the secondary school mathematics landscape in Nigeria.

Teacher and Student Perceptions: Asanre, Tai & Odupe (2023) found that in Remo, Ogun State, teachers' perceptions, attitudes and experiences toward integrating AI into mathematics teaching were generally high. Similarly, a study in Wukari Metropolis, Taraba State showed both mathematics teachers and SS2 students are familiar with AI and are supportive of using AI tools in mathematics lessons; respondents indicated that AI enhances learning experiences.

Empirical Intervention Studies: One recent quasi-experimental study in Ogun Central Senatorial Districts showed that integrating AI-based instructional materials for teaching geometry significantly improved students' understanding and retention of geometric concepts. The study also found positive teacher and student perceptions of the integration.

Policy and Structural Analyses: Research on "AI Education in Nigerian Schools" has flagged both possibilities and impediments: AI can be used in intelligent tutoring, virtual learning environments, administrative tasks, and data management, among other areas. But there are deficits in funding, infrastructure (electricity, internet, hardware), teacher training and curriculum integration. In another study, Aliyu and Zaitawa (2024) note that AI technologies could reshape instructional methods toward more learner-centred approaches in secondary schools, particularly given the diversity of student learning needs and resource constraints.

Specific Case on ChatGPT and Large-Language Models: A study examined the transformative role of ChatGPT in mathematics instruction, discussing opportunities such as instant feedback, explanation generation, and assistant support, but also highlighted concerns (e.g. accuracy, misuse, ethical issues).

Thus, while AI has begun to enter Nigerian secondary mathematics education, its penetration is patchy, uneven and often limited to pilot studies, certain states or schools, or non-systematic usage.

Implications of AI for Mathematics Education

Integrating AI into mathematics education in Nigerian secondary schools has multiple implications both positive and challenging.

1. Potential Benefits

Personalization and Adaptive Learning: AI can tailor instruction to individual student's pace, style and gaps. For instance, students who struggle with particular topics (e.g., geometry) can get extra practice, while others progress to deeper tasks. The Ogun geometry study showed improved retention among students exposed to AI-based instructional materials.

Immediate Feedback and Assessment: AI tools (e.g., intelligent tutoring systems, chatbots) allow for quicker and for students more informative assessment. Teachers

are less burdened with grading, enabling more time for pedagogical planning or one-on-one support. Studies in Nigeria showed that AI can automate assessment and adapt to student performance.

Improved Engagement and Motivation: Interactive or adaptive AI tools can make mathematics more engaging. Students often find AI tools novel and responsive, increasing their interest. Perception studies record that students appreciate when AI is used in class.

Teacher Support and Professional Development: AI can support teachers by providing analytics about student performance, suggesting remediation strategies, or curative resources. Additionally, AI tools can be used for teacher training.

Equity and Access (conditional): If deployed well, AI may help bridge resource gaps: for instance, in rural schools or schools with few qualified teachers, AI-augmented tutorial or tutoring systems might compensate. However, this depends heavily on infrastructure.

2. Challenges and Risks

Infrastructure Deficits: Many Nigerian secondary schools suffer from unreliable electricity supply, insufficient or no internet connectivity, lack of hardware (computers, tablets) and lack of maintenance. Without solving these, AI adoption will be constrained.

Teacher Preparedness and Capacity: Teachers often lack training in both AI technology and pedagogies for integrating these tools. Resistance or low confidence in using AI can limit adoption.

Cost and Funding: Hardware, software, licensing, maintenance, connectivity all cost money. Funding, especially in public schools and in low-income areas, is often inadequate.

Curriculum, Policy and Regulatory Gaps: The national / state curricula may not explicitly include AI tools or guidance on pedagogical innovation. Regulatory frameworks (for data privacy, ethical AI usage) may be weak or lacking.

Equity and Access Concerns: Even where national policy exists, differences in socio-economic status, urban versus rural, public versus private schools, may produce unequal access to AI resources. Vulnerable students may be left further behind if uneven implementation is not addressed.

Pedagogical Risks: Over-reliance on AI tools could reduce opportunities for human interaction, teacher mediation, or creativity; risk of students depending too much on automated responses; possibly superficial learning if AI tools are not well designed; possibility of algorithmic bias or content not suited to local context.

Ethical, Privacy and Cultural Concerns: Use of AI tools may raise issues around data privacy, potential misuse of student data, uneven content (cultural relevance) and the possibility of exacerbating existing inequalities.

Role of Innovations in Mathematics Education in Nigeria

Innovation in mathematics education in Nigeria in connection with AI and outside of pure technology, has already taken several forms and more are possible.

Adaptive and AI-Enabled Instructional Materials: As in the Ogun Central geometry study, using AI-based materials that adjust difficulty, pace and provide interactive visualizations or simulations helps students grasp complex geometric ideas better.

Chatbots and Conversational Agents: Tools like ChatGPT are being explored as assistants in mathematics classes, offering explanations, answering questions, guiding problem solving. Ebhomien & Omokhomion (2025) discuss how ChatGPT can transform mathematics education, especially in areas of feedback, scaffolding, and helping students pose questions.

Productive Pedagogies and Communities of Practice: Innovation is not only about the tools but about how teaching is organized. For example, studies implementing productive pedagogies (promoting intellectual quality, connectedness, supportive classroom environment, recognition of difference) via communities of practice among teachers have shown improvements in teaching quality.

Learner-Centered Activity-Based Methods: Including hands-on activities, mathematics laboratory work, collaborative learning, project-based tasks that force students to apply mathematics in novel contexts. For example, teaching mathematics in junior secondary classes with creative, hands-on lessons was found to foster better understanding.

Local Content and Cultural Innovation: Using culturally relevant examples, local contexts, indigenous problems in mathematics tasks to make mathematics meaningful, which aids motivation and comprehension. Though less well documented, this form of innovation is consistent with creativity research.

Hybrid/Blended Models: Combining AI tools with traditional classroom instruction, ensuring human oversight, peer learning, group problem solving, using AI for supplementary support or for remedial work.

Role of Creativity in Mathematics Education in Nigeria

Creativity must play a central role in any educational reform, especially in mathematics.

Creative Thinking by Teachers: Teachers must design tasks that are open-ended, allow exploration, multiple solution paths, encourage conjecture, reasoning. Studies in Cross River State found that a more creative classroom environment and creative communication by teachers significantly influence students' learning of mathematics.

Stimulating Student Creativity: Encouraging students to pose their own problems, explore mathematics beyond standard examples, use mathematics in project work, contests, models, art and design. For example, mathematical creativity considered as a means to technological advancement and employability in Nigeria.

Creativity in Assessment: Use of non-routine problem solving, real-world tasks, performance assessments, portfolios. AI can assist by generating variant problems, adaptive assessments and peer assessments.

Creative Use of AI: Not using AI simply to replicate existing pedagogy, but to re-imagine how mathematics is taught: for example, integrating visualization, simulations, interactive geometrical models, AR/VR, collaborative coding and

computational exploration. Also ensuring tasks allow for divergent thinking multiple approaches.

Innovation & Creativity Synergy: Innovation (new tools/methods) supports creativity; creativity demands innovation. The two are interdependent.

Summary

This article reviewed literature and empirical studies to understand the potential of AI, innovation and creativity in transforming mathematics education in Nigerian secondary schools. AI is already being adopted in pilot studies and in certain states, with positive outcomes in student performance (e.g. geometry), teacher and student perceptions, and engagement.

Significant barriers remain: infrastructure, teacher training, curriculum alignment, policy, equity. Innovation in pedagogy (activity-based, hands-on, blended learning) and creativity (open-ended tasks, student-centered learning) are essential complements to AI to ensure deeper understanding and more meaningful learning. Without addressing systemic challenges, AI may widen rather than close gaps.

Conclusion

Artificial Intelligence, combined with innovation and creativity, has substantial potential to revolutionize mathematics education in Nigerian secondary schools. When properly leveraged, AI can enhance personalization, feedback, student engagement, teacher efficiency and ultimately student outcomes. However, realizing this potential demands more than introducing technology: it requires systemic reforms in policy, infrastructure, teacher capacity, assessment practices and equity considerations. Innovation and creativity must not be afterthoughts, but central pillars, ensuring that mathematics learning is not mere rote or routine but intellectually stimulating, relevant and adaptive to 21st-century needs. If Nigeria can address the existing barriers and commit to strategic, inclusive implementation, its secondary mathematics education can better prepare students for higher education, for employment and for active participation in a rapidly changing world.

Recommendations

Based on the review, the following recommendations are proposed to policymakers, educational stakeholders, school practitioners and researchers:

1. **Policy Formulation and Regulatory Frameworks:** Federal and State Ministries of Education should develop explicit policies for AI integration in secondary school mathematics, including standards for tools, data privacy, and ethics. Curricula (at junior and senior secondary levels) should be revised to incorporate AI-supported instruction, digital literacy and computational thinking.
2. **Infrastructure Investment:** Ensure reliable electricity, broadband internet, and provision of hardware (computers, tablets) especially in rural and under-resourced schools. Establish and support mathematics laboratories with access to software, visualization tools and simulation platforms.
3. **Teacher Professional Development:** Pre-service and in-service teacher training programmes must include AI tools, pedagogies for innovation and creativity and strategies to integrate these in mathematics teaching. Create

communities of practice among teachers to share best practices, experiment with new techniques and reflect on innovation.

4. **Equitable Access and Inclusion:** Ensure AI tools are affordable or subsidized; consider public-private partnerships. Address gender, socio-economic and geographic disparities in access to AI technology and digital tools.
5. **Curriculum and Pedagogical Innovation:** Incorporate activity-based, learner-centered, problem-based learning approaches. Use open-ended tasks, real-world problems, project based work that require creative thinking. Integrate AI tools that support these pedagogies rather than merely digitalize traditional lecture-driven instruction.
6. **Supportive Assessment Practices:** Develop assessments that measure not only procedural fluency but conceptual understanding, creativity and problem solving. Use AI-assisted assessment tools for formative evaluation, diagnostics and feedback to learners.
7. **Research, Monitoring and Evaluation:** Conduct large-scale studies assessing long-term outcomes of AI and innovation/creativity interventions. Monitor equity, effectiveness and unintended consequences. Encourage local innovation and adaptation of AI tools to Nigerian contexts (language and cultural relevance).

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