RELEVANCE OF ARTIFICIAL INTELLIGENCE (AI) AS A TOOL TO ENHANCE TEACHING AND LEARNING OF MATHEMATICS.

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Abstract
The use of digital tools in education is growing rapidly worldwide, especially with the wider availability of artificial intelligence (AI) technologies. Using AI in education supports personalized learning but also shows the need for updated teacher training and curriculum to prepare educators for new responsibilities. The study explores various AI- powered tools and its application in the learning of mathematics, the developmental trajectory, practical implementations, and strategic applications of AI in mathematics education, highlighting how AI-driven approaches can foster deeper understanding, creativity, and increased productivity in learning outcomes. Furthermore, it identifies key factors influencing the effective integration of AI technologies in mathematics instruction. The position underscore AI's transformative potential to enrich curriculum delivery and learner engagement. The paper advocates for the systematic incorporation of AI tools in mathematics classrooms, recommending targeted professional development and workshops to equip educators with the skills necessary for maximizing AI's educational benefits.

Keywords: Relevance , Artificial Intelligence, Mathematics Education, AI Tool, Personalized Learning, Intelligent Tutoring System

Introduction

The use of digital tools in education is growing rapidly worldwide, especially with the wider availability of artificial intelligence (AI) technologies. This growth is driven by the need for educational systems that are more effective, flexible, and focused on the learner. Artificial Intelligence (AI) refers to the capability of a computer, machine, or robot to perform tasks that usually require human intelligence (Mellor, 2022). Similarly, Frankenfield (2023) defines AI as software designed to imitate human thinking. The field of AI studies how to create and improve computers that can enhance human intelligence. According to Alagbe et al. (2021), AI allows machines to copy human mental processes, such as learning from experience, recognizing objects, understanding and responding in language, making decisions, and solving problems. These abilities let machines perform tasks a human could do, such as tutoring or simulation. AI is changing traditional education by providing real-time data analysis, automating administrative work, and tailoring teaching to meet the needs of each student (Liu et al., 2021). Both teachers and learners now need to develop skills in digital technology and AI, reflecting a major change in educational policies and teaching methods (George, 2023).

AI also supports teachers' training and ongoing development. Online courses powered by AI help teachers improve their skills in ways that meet their specific needs. AI can track how teachers perform and suggest ways to improve, which helps raise teaching quality (Ezenwobodo, 2024; Moss, 2021). This tailored support helps both teachers and students by improving understanding in subjects like mathematics and addressing personal learning challenges.

Walter (2024) highlights the importance of making critical thinking a practical part of classroom teaching and teacher training. Using AI in education supports personalized learning but also shows the need for updated teacher training and curriculum to prepare educators for new responsibilities.

In Nigeria, AI could transform how math teaching is done by offering teachers adaptive online courses and resources to improve both their teaching methods and subject knowledge. AI can design learning plans for teachers that consider their personal needs and areas where they want to improve. This ensures teachers get the help they need to succeed in the classroom (Ezenwobodo, 2024).

Finally, incorporating AI can also help in evaluating teachers' performance and provide feedback and suggestions for improvement. This feedback helps teachers customize their lessons to each student's unique needs and learning style (Moss, 2021). Such support motivates students, makes learning more enjoyable, helps students find and solve their weaknesses, and strengthens their understanding of mathematics.

Evolution and Milestones in AI-Enhanced Education

The integration of digital tools into science and mathematics education predates the emergence of modern artificial intelligence by several decades. Early applications can be traced to computer-aided instruction (CAI) models developed during the 1960s and 1970s. These systems presented instructional content in fixed sequences and provided basic drill-and-practice routines (Hao et al., 2024). Although innovative for their time, such systems lacked interactivity and adaptability, functioning primarily as automated flashcards or procedural problem generators.

By the 1980s and 1990s, educational developers began adopting constructivist approaches, emphasizing learner engagement through interactive visual simulations and problem-solving modules in mathematics and physics. Despite these advances, the systems of this period still required manual configuration and offered minimal feedback mechanisms. With the expansion of personal computing and internet access, web-based learning platforms emerged, enabling greater flexibility in content delivery, though their pedagogical frameworks largely remained static (Jong et al., 2024).

A major advancement occurred in the early 2000s with the introduction of Intelligent Tutoring Systems (ITS). These platforms integrated domain-specific knowledge with learner modeling techniques, enabling adaptive feedback and dynamic content sequencing. Notable among them was the Cognitive Tutor for Algebra, developed by Carnegie Learning, which employed Bayesian networks to diagnose student misconceptions and tailor individualized practice sessions (Adiguzel et al., 2023).

The advent of AI-enhanced learning environments further transformed mathematics and science instruction. Built upon machine learning, natural language processing (NLP), and real-time data analytics, these platforms provided scalable and highly personalized learning experiences.

Key Milestones in AI-Enhanced Learning

Rule-Based Systems (1980s): The earliest AI applications in education adopted rule-based intelligent tutoring frameworks that provided procedural guidance and answer verification.
Problem-Solving Tools (1990s): The development of dynamic geometry software and visualization tools introduced AI-driven problem-solving and interactive modeling capabilities.
Expansion and Personalization (2000s–2010s): The wider adoption of machine learning algorithms enabled systems to predict student performance and deliver personalized feedback, incorporating cognitive modeling and adaptive learning techniques.
Deep Learning Era (2010s–Present): Advances in deep learning facilitated more sophisticated analyses of learner behavior and cognition, recognizing the diverse and individualized nature of students' conceptual understanding.

Application of AI in Mathematics Education

Artificial Intelligence (AI) is profoundly transforming mathematics education by facilitating personalized, adaptive, and data-informed learning processes. Prominent Intelligent Tutoring Systems (ITS), including Carnegie Learning's MATHia and ALEKS, leverage AI to assess learners' individual knowledge states and dynamically tailor instructional pathways, thereby enhancing student engagement and comprehension (Moss, 2021).
Key AI systems and their contributions to mathematics include AlphaTensor, which addresses challenges in matrix multiplication and discovery; formal proof assistants such as Lean, Coq, and Isabelle that facilitate rigorous theorem proving; adaptive learning platforms ALEKS and DreamBox focused on diagnostics and personalized learning; computational support tools like MathGPT and Wolfram Alpha providing detailed solution pathways; and reinforcement learning models from Meta AI applied to symbolic integration and mathematical optimization.

AI-Power Tools for Teaching and Learning of Mathematics
AI-powered tools are revolutionizing mathematics education by providing personalized tutori ng, instant problem-solving, and interactive visualizations that adapt to individual student needs, making abstract concepts more accessible and engaging for both learners and teacher. Some instances that explores how AI can be use in the teaching and learning are provided below

Virtual Mentor
Mentoring has traditionally been a vital practice across many industries, cultures, and educational environments, designed to nurture professionals and help advance their careers through the exchange of knowledge. It typically involves experienced mentors providing guidance and support to protégés, while building trusting and empathetic relationships (Eby et al., 2018). This human-centered method fosters the growth of tacit knowledge, professional identity, and social networks—elements that are challenging for impersonal systems to reproduce. With the rapid progress of artificial intelligence (AI) and related technologies, new opportunities and challenges arise for conventional mentoring. AI-driven mentoring platforms can scale support by personalizing learning paths, analyzing career data, and offering instant feedback to mentees (Garg et al., 2023). Nevertheless, mentoring remains essential for personal and career development because it emphasizes individualized human connections that promote skill enhancement and knowledge transfer.
Several AI-powered tools demonstrate how technology can support and extend mentoring efforts. Blackboard, commonly used in universities throughout Europe and America, enables educators to upload lecture materials, assign tasks, create quizzes, and administer tests, while allowing students to ask questions and submit work. This facilitates ongoing communication and assessment, streamlining access to resources, feedback, and supporting adaptive learning.
Other notable AI-based educational tools include Photomath, which uses a smartphone camera to scan handwritten or printed math problems and then provides step-by-step solutions, helping learners grasp concepts from basic arithmetic to calculus. Mathway covers a wide range of math topics such as algebra and statistics, offering detailed explanations that encourage conceptual understanding rather than just providing answers. Microsoft Math Solver combines problem scanning with interactive graphing and visual tools, benefiting learners studying geometry and complex functions. Collectively, these technologies highlight how AI can enhance traditional mentoring by delivering personalized, prompt, and scalable educational assistance.

Voice Assistant (VA)
The development of AI-driven voice assistants has been widely studied across industries, with applications in personal assistance, customer service, and, more recently, education. voice

assistants incorporate Natural Language Processing (NLP) with differerent capabilities and speech recognition accuracy, as seen in studies by Liu and Wang (2021), who reviewed advancements in NLP and their applications in academic support tools, Voice assistants like Apple's Siri, Amazon's Alexa, and Google Assistant paved the way for academic applications by demonstrating the feasibility of voice-activated technology in daily life. The voice assistant can be integrated with popular online learning platforms (e.g., Coursera, edX, and NPTEL) and college management systems. This integration would allow the assistant to fetch up-to-date course materials, video lectures, and assignments from these platforms and provide real-time updates to students about course deadlines, grades, and notifications.it give room for student to learn independently without worrying about getting confused even without a teacher.

Personalized learning

AI-powered adaptive learning platforms such as DreamBox and Smart Sparrow enhance personalized learning needs by analyzing student data and adjusting content in real-time. DreamBox, for instance, continually assesses each student's strengths and areas for improvement in subjects like math, automatically adjusting lesson difficulty to match their learning level. Smart Sparrow, on the other hand, uses interaction data to customize e-learning experiences across disciplines, such as biology, ensuring content aligns with each student's progress. Other examples of the application of personalized learning are Magic School, Duolingo, Quizizz, Otter.ai which support lesson planning and have over 40 student tools for tailored practice, integrating with platform like google classroom. These platforms allow students to move at their own pace, making learning more effective and tailored to individual needs. By leveraging the capabilities of AI, these platforms adapt dynamically to each student's unique progress (Jian,2023)

AI-Assisted Virtual Laboratories and Simulation

Traditional laboratory learning, while essential, is often limited by time, cost, safety concerns, and unequal access to physical resources. Virtual laboratories address these barriers by offering interactive, immersive platforms where students can replicate experiments, visualize outcomes, and receive intelligent guidance throughout the process (Estevez, et al., 2019).

Platforms like Labster, Beyond Labz, and Late Nite Labs simulate real-world lab environments, including glassware, reagents, instruments, and data output systems. These systems go beyond static animations; they allow students to make decisions in real time—choosing chemicals, adjusting procedures, or controlling reaction conditions—while the AI monitors progress and provides feedback (Oluwafemi,2024).

The core innovation lies in the AI coaching layer. When students deviate from correct experimental protocols, the system flags errors and suggests corrective actions. For example, if a student incorrectly titrates a sample or forgets to calibrate equipment, the AI assistant intervenes with prompts that mirror instructor guidance. By incorporating these technologies into the curriculum, educators can design interactive and stimulating learning environments that foster critical thinking and problem-solving skills among students.

Adaptive Learning Technologies

AI-powered adaptive learning systems personalize education and enhance student outcomes by analyzing performance data and adjusting content difficulty in real-time (Onesi-Ozigagun et al., 2024). By adapting to individual learning paces and providing targeted support, they meet diverse student needs in Nigerian classrooms, thereby boosting engagement and performance. Integrating AI requires balancing technology-driven personalization with human interaction with teachers as facilitators (Idowu, 2024). AI-driven adaptive learning can transform Nigerian education into a personalized experience. Success depends on addressing ethical issues,

developing educators' skills, and establishing transparent systems (Castro et al. 2024; Ejjami 2024). As AI evolves, its educational impact is expected to grow, enhancing learning outcomes and preparing students for the digital age (Onesi-Ozigagun et al., 2024). Examples of this include DreamBox,Knewton,and smart Sparrow.

Intelligent Tutoring Systems

Artificial Intelligence has transformed the delivery of mathematics education through intelligent tutoring systems (ITS) specifically tailored for algebra, calculus, and geometry. These systems emulate the role of a human tutor, offering personalized guidance, immediate feedback, and scaffolding based on learner progress. Widely adopted platforms such as MATHia, Carnegie Learning, and ASSISTments integrate AI algorithms to support students in mastering procedural fluency, conceptual understanding, and strategic problem-solving (Rudolph,et al 2023).

Strategies for Integrating Ai in Teaching and Learning of Mathematics

Mathematics teaching strategies are a set of tools that provide support to teachers, similar to navigation systems for travelers. Mathematics education is also constantly developing. Mathe matics teaching strategies and methods that were popular several years ago are now being rep laced by more effective research and Big Data-based methods aimed at making mathematics a more accessible and meaningful subject (Persico, 2019).

Open-Endedness Strategy

The open problems can improve students' understanding and promote mathematical creativity by motivating students to develop their ideas. Tasks are considered open if their starting or target situation is not specified. Open problems usually have more than one solution and can be accomplished in more than one way. This leaves students free to solve the task and allows them to use different ways of thinking. Open problem learning activities are provocative and stimulate different thinking on a particular topic. Teachers' attitudes, assessment criteria and procedures are essential in this process, encouraging students to choose different solutions and offer creative answers. Students have the opportunity to express themselves as creative mathematicians.

Visual Representation

The adage "a picture is worth a thousand words" holds particular significance in mathematics, where visual models enhance comprehension of abstract concepts and facilitate problem solving. Advances in computer imaging have led to the field of visual mathematics, enabling artificial intelligence to help students systematically analyze geometric structures and mathematical formulas. Today, many students have a visual perception. They learn the topic best when they can see what is happening, and a non-visual approach can even hinder their efforts to solve the problem.

Blended Learning

Due to the Covid virus most schools around the world switched to distance learning using the benefits of technologies. And it is now absolutely clear that in the future, in addition to traditional teaching methods, digital solutions will also stand, giving students a taste of modern education with the utilization of AI . Blended learning solutions (Edsys, 2020) will become increasingly popular, aiming to ensure optimal digital infrastructure requirements while preserving traditional learning resources.

Flipped learning

Flipped learning is defined as a pedagogical approach that direct instruction moves out of the class via technology and internet (e.g. videos, podcasts, online blogs or available online materials.) it can also be defined as a pedagogical approach in which the conventional notion of classroom-based learning is inverted so that students are introduced to the learning material before class with classroom time then being used to deepen understanding through discussion with peers and problem-solving activities facilitated by teachers (Eze, 2023) AI support flipped learning by personalizing pre-class content delivery, providing real-time feedback and adaptive tutoring, and enabling data-driven in-class interaction.

Collaborative Learning

Collaborative learning is a teaching approach involving joint intellectual effort by students, or students and teachers together. Usually, students are working in groups of two or more, mutually searching for understanding, solutions, or meanings, or creating a product. Collaborative learning activities vary widely, but most center on students' exploration or application of the course material, not simply the teacher's presentation or explication of it (Amina, et al.,2024).

AI facilitates collaborative learning by personalizing group activities, mediating interactions with chatbots and real-time feedback, automating tasks for teachers, and enabling new forms of teamwork like AI-assisted brainstorming, ensuring equitable participation, improving communication, and fostering deeper understanding through adaptive support and role assignment based on individual strengths. It acts as a partner by identifying common themes, suggesting discussion points, and helping students resolve conflicts, leading to more effective group outcomes.

Project-based learning (PBL)

Project-based learning (PBL) is a teaching and learning method that drives students' learning by engaging them in real-world, meaningful projects. It's a style of inquiry-based and student-centered learning. In PBL, students work in groups over a set period on a project designed to solve a genuine problem or answer a challenging question. Students demonstrate their knowledge and skills by creating a product or presentation for a public audience. Project based learning activities allow students to develop deep content knowledge(Agboola,2024) Integrating project-based methods is essential for captivating students through AI interactions. Schools must offer access to AI-driven tools and platforms enabling students to explore coding, data analysis, and machine learning hands-on.

Drawbacks in Utilization of AI in Teaching and Learning of Mathematics

Teacher Training and professional development

Integrating AI tools into existing curricula presents logistical and pedagogical challenges. Teachers may require specialized training to effectively incorporate AI into their teaching methods, and existing educational frameworks may need to be adapted to accommodate these technologies. Without adequate support and professional development, the potential benefits of AI in education may not be fully realized. As AI becomes increasingly sophisticated, it offers educators powerful tools to enhance their instructional practices, personalize learning experiences, and improve student outcomes. Through training programs and professional development initiatives, teachers can develop a solid grasp of AI concepts, applications, and ethical considerations. This foundational knowledge empowers educators to make informed decisions about incorporating AI tools into their teaching practice and navigating ethical challenges.

Privacy and Data Security

AI applications often rely on collecting and analyzing large volumes of personal data, raising concerns about student privacy and data security. Educational institutions must ensure compliance with data protection regulations and implement robust security measures to safeguard sensitive information. Failure to address these concerns can undermine public trust and hinder the adoption of AI technologies in education (Oluwafemi, 2024)

Bias in AI Models and Limitations in Cultural Responsiveness

Algorithmic bias is a persistent challenge in AI-enhanced education tools. Most machine learning models are trained on historical datasets that often mirror societal inequalities, such as disproportionate discipline rates or access to advanced STEM coursework. When such datasets are not balanced, AI systems may learn to associate academic underperformance with demographic features, perpetuating exclusionary patterns (Niess,2005)

In mathematics learning platforms, for example, certain dialects or cultural problem-solving approaches may be misinterpreted by natural language processing engines. A student using region-specific terms or representations may receive inappropriate feedback simply because the model was not trained on diverse linguistic inputs. This not only impairs learning but also risks alienating students from different cultural backgrounds (Kaspersen,2025)

Conclusion

The utilization of AI suggests that robust external support is critical for effective AI integratio n. For instance, Tondeur et al. (2017) and Xiong and Lim (2015) highlighted that policy m andates and administrative support significantly enhance technology adoption in schools. adv anced technological infrastructure directly facilitates AI utilization. Parental and community e ngagement also plays a crucial role, as supportive attitudes and active participation from thes e stakeholders create a favorable environment for AI utilization in schools. professional devel opment and continuous support are vital for building teachers' technological competencies an d fostering positive attitudes towards technology integration. By addressing direct and indire ct influences, this study provides a nuanced understanding of the dynamics in AI utilization.

Recommendation

- Policies encouraging AI utilization can lead to higher adoption rates among mathemat ics teachers. Similarly, the availability of technological infrastructure, such as high-speed Internet and smart devices, is essential for AI integration.
- Beyond these direct relationships, the paper suggest important implications for the ind irect effects of external factors mediated through internal factors. External conditions such as policy support and community engagement can enhance mathematics teacher attitudes toward AI and their TPACK, thereby indirectly boosting AI utilization in teaching and learning.
- Policies to enhance technological infrastructure should be accompanied by profession al development programs to build teachers 'confidence and TPACK in using AI tools.
- Comprehensive approach ensures that teachers are equipped with the necessary tools and infrastructure and supported through professional development and community engagement
- Encouraging project based-learning (PBL) by having students work on real -world project that apply AI tools to solve practical problems. This hands-on experience helps develop critical thinking, collaboration and technical skills. Provide access to AI-powered tools and platforms that allow students to experiment with coding, data analysis, and machine learning, thereby encouraging creative exploration and problem -solving.
- Evaluating and monitoring AI tools in educational environments is crucial for assessing their efficacy and impact on teaching and learning outcome. Educators need

to regularly evaluate the performance of AI tools to ascertain if the align with the intended objectives and promote student engagement.

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