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Artificial Intelligence in Mathematics Education in Teacher Training Institutions: Prospects and Challenges

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Abstract

The study investigated the prospects and challenges associated with the adoption of artificial intelligence in mathematics education in teacher training institutions. The study was done in Imo State, Nigeria, using the Alvan Ikoku Federal University of Education in Owerri. Two research questions guided the study based on the objectives. The descriptive survey research design was adopted in the study. The sample for the study was made up of all students in the mathematics education department of the institution, based on the census sampling technique. The instrument for data collection was a researcher-constructed 4-point Likert-type questionnaire titled "Prospects and Challenges of Artificial Intelligence in Mathematics Education (PCAIME)" with a reliability coefficient of 0.81 determined through Cronbach's alpha formula. The data generated was analyzed using the mean and standard deviation to answer research questions. The result of the study revealed that artificial intelligence (AI) contributes immensely to the development of mathematics education through various tools. It was also revealed that various factors constitute a challenge to the adoption of AI in mathematics education, which include a lack of technological competence, a lack of technological facilities, poor power supply, data management, and others. Based on the findings, it was recommended that artificial intelligence be gradually implemented in the teaching and learning of mathematics in teacher training institutions in Imo State.

Keywords: *Artificial Intelligence, Mathematics Education, Prospect Challenges.*

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Introduction

Mathematics is an important subject that determines the technological development and economic vibrance of any nation. Mathematics plays an important role in the development of the sound mind and intellectual wellbeing of individuals in any society. The study of numbers, amounts, structures, space, and change is known as mathematics. It uses rigorous deduction and logical reasoning to define and comprehend properties, relationships, and patterns. As a vital tool for comprehending the natural world, mathematics helps us to solve issues in a variety of disciplines, including science, engineering, economics, and more. It also allows us to model phenomena and make predictions. It covers everything from simple geometry and arithmetic to more advanced subjects like algebra, calculus, number theory, and mathematical logic. Since mathematics offers a methodical approach to describing and analyzing the cosmos, it is frequently referred to as the language of science. Obafemi et al. (2024) said that it is generally accepted that having a solid understanding of mathematics is necessary for the advancement of science and technology, both of which are critical to the socioeconomic growth of a country. It was also claimed that mathematics is essential to many human endeavors and is a key driver of advances in science and technology. Mathematics is an essential component of human reasoning and logic, and it lays the foundation for many scientific disciplines. Since mathematics education has the ability to address a number of the social and economic issues the nation is currently facing, it has been designated as a critical area for improvement in Nigeria (Otikor, 2023). Ezenwobodo (2023) showed that mathematics is a basic subject and that students who want to work in the fields of science, technology, engineering, and mathematics (STEM) need to be proficient in it.

This important subject is the most hated in the education system, as both teachers and students find it difficult in the teaching and learning process. Students are noted to come into higher institutions with a very low understanding of concepts, leading to poor problem-solving ability in the subject, which is exhibited in their achievements. Teachers, on their part, find it difficult to transmit the accurate knowledge and skills required for problem solving in the 21st century. This stems from their non-application of student-centered and motivating instructional approaches. At the higher education level, the predominant lecture method has been outmoded as a result of the dynamic nature of society. The 21st century requires educational approaches that will foster creativity, collaboration, critical thinking, and communication (4Cs) among students, especially in the field of mathematics. The advent of technology in education has brought with it numerous benefits, including the capability to transmogrify the pedagogical difficulties associated with mathematics education. Supporting this, Ertmer (2019) reported that educational scholars have extensively explored the transformative potential of technology in reshaping traditional teaching paradigms. Okunade (2024) stated that the traditional teaching methods used in a number of schools might not be able to successfully engage and inspire students, which could lead to a decrease in their interest in science-related courses. It was also mentioned that these issues are made worse by the scarcity of modern teaching resources and technologies, which calls for creative solutions that might completely change the way science is taught. The adoption of emerging technologies such as artificial intelligence has the potential to render a shift in the pedagogical paradigm in mathematics education.

The multidisciplinary discipline of computer science known as artificial intelligence (AI) is dedicated to building devices, software, or systems that can carry out tasks that normally require human intelligence. These tasks cover a wide range of abilities, including decision-making and problem-solving, as well as comprehension of natural language and pattern recognition in data (Ezenwobodo, 2024). Saini (2022) opined that the ability of

machines to carry out cognitive functions including thinking, seeing, learning, solving problems, and making decisions is known as artificial intelligence (AI). It was influenced by how people utilize their minds to observe, comprehend, reason through, and choose what to do. In the words of Alagbe et al. (2021), artificial intelligence (AI) is the ability of a computer or machine to mimic the capabilities of the human mind, learning from examples and experience, recognizing objects, understanding and responding to language, making decisions, solving problems, and combining these and other capabilities to perform functions a human might perform, such as greeting a hotel guest or driving a car. Artificial intelligence (AI) has the ability to offer solutions to all education-and non-education-related problems with perfection through mimicking the human mind and brain. Some of the artificially intelligent tools for teaching mathematics include chatbots, data analytics, machine learning algorithms, educational games, and gamification. Aina et al. (2023) noted that within the realm of education, artificial intelligence (AI) offers a multitude of possibilities to augment the learning process. Intelligent systems provide the ability to adjust to the specific requirements of each learner, deliver tailored learning experiences, and provide immediate feedback. Ogunode and Olowonefa (2023) stated that artificial intelligence (AI) can be used to prepare student results, support effective learning, implement instruction (intelligent tutoring) effectively, create virtual learning environments, and manage data effectively. Realizing the significance of artificial intelligence (AI) technologies on students' engagement in mathematics education. Sinha (2023) suggests that applications for augmented reality (AR) and virtual reality (VR) offer aesthetically appealing depictions of abstract mathematical ideas. Students can perceive complex functions in a dynamic virtual realm, move items to comprehend spatial relationships, and investigate three-dimensional geometric structures. These can sustain the students' interest and commitment to learning mathematics. The use of AI as an innovative tool in teaching and learning mathematics will enhance both teachers and students problem-solving skills and position them adequately in the current technologically dynamic society. Abu (2024) claimed that long thought to be insurmountable, complex mathematical problems can now be solved with the help of artificial intelligence. AI is transforming mathematics in a number of ways due to its speedy processing and analysis of large volumes of data. Artificial intelligence can be used to identify and help struggling students and slow learners in mathematics, thereby bringing them up to speed. Considering the importance of AI in mathematics education, Wu (2021), in a research report, asserted that basic mathematics education and instruction have greatly benefited from the introduction of AI-assisted teaching. Pai et al. (2020), evaluating the pedagogical efficacy of an intelligent tutoring system intended to assist students in strengthening their multiplication and division skills, discovered that the system enhanced students' mathematical learning as well as their motivation to learn. Sinha (2023) claimed that by giving students immediate feedback and detailed instructions, the AI system improves their understanding of the problem-solving process. AI gives students the tools they need to become competent problem solvers and independent learners by fusing real-time feedback with iterative practice. Ogunode et al. (2023) noted that Al can assist educators in creating educational materials, including smart content, that will facilitate the delivery of instruction or lectures wherever they are. Canonigo (2024) investigated the transformative impact of integrating AI into mathematics education, focusing on the effects of AI tools, such as GeoGebra and ChatGPT on students' conceptual understanding and self-efficacy in mathematics classroom setting with focus on collaborative learning, teacher-led discussions, and problem-solving. The study revealed a noteworthy enhancement in students' conceptual understanding and self-efficacy belief when AI tools are incorporated into mathematics education. However, it highlights concerns such as technological challenges, potential teacher replacement fears, biases in AI systems, and difficulties related to pacing and social interaction. Song et al (2025) investigated teachers

and learners' perceptions about implementation of AI tools in elementary mathematics classes, the study revealed that, employment of AI tools, led to a notable increase in learners' general mathematics performance and problem-solving ability. Wardat et al (2024) investigated mathematics teachers' perceptions of implementing AI systems and applications in Abu Dhabi Emirate schools. The result of the study revealed that Ai could be used as an educational tool to facilitate teaching and develop students' performance by including AI systems and applications in the curricula. They increased motivation for learning, encouraging challenge, competition, and suspense among students and considering their differences. The result showed the most critical challenge mathematics teachers face in applying AI systems and applications to include the need to exert more effort than the traditional method when using different AI systems and applications and the pressure placed on them, which prevent them from using AI in teaching.

Despite all of the advantages that artificial intelligence (AI) technologies offer in the field of mathematics education, they cannot completely replace professors in the classroom; rather, they are a necessary tool that helps them give lectures more effectively. By giving students immediate feedback and detailed instructions, the AI system improves their understanding of the problem-solving process. AI gives students the tools they need to become competent problem solvers and independent learners by integrating iterative practice with real-time feedback (Sinha, 2023). Olusegun and Honmane (2024) acknowledge the significance of artificial intelligence in mathematics education. Tertiary institutions in Nigeria have proposed that it improves the way mathematics lectures are presented, how student results are prepared, how mathematical instructional resources (Smart Content) are created, how mapping and modeling work, how automated simulation works, how automated modeling is implemented, how mathematics research is developed, how well exams are administered, how motivated and engaged students are in mathematics, and how personalized learning is strengthened. Ogunode and Ejike (2023) stated that artificial intelligence (AI) supports efficient classroom administration, course presentation, increased learner engagement, exam conduct, online teaching and learning, quick result preparation and marking, and efficient school security.

Irrespective of the genuine contributions of artificial intelligence in education, several barriers have been reported by researchers that hinder its deployment in teaching and learning. For instance, Smith and Brown (2019) indicated that resistance to emerging technologies and a lack of technological proficiency were barriers to the adoption of AI. Mafara and Abdullahi (2024) indicated difficulties in using AI in an enable classroom to address the digital divide and avoid exacerbating existing inequalities that are already in existence and lack of adequate infrastructure, such as reliable internet connectivity, electricity, and devices, that are essential for the delivery and use of AI-based educational solutions as challenges associated with AI adoption in education.

The literature in the study has given insight on the importance and related barriers to the adoption of artificial intelligence in education at various levels. However, the adoption of artificial intelligence (AI) is still at a preliminary stage, and none of the reviewed studies was carried out within the area of the present study, which leaves a notable gap in knowledge. Therefore, the researcher deemed it necessary to unravel the prospects and associated challenges of the adoption of artificial intelligence (AI) in mathematics education in teacher training institutions in Imo State, Nigeria.

Purpose of the Study

The purpose of the study was to examine the prospects and challenges of the adoption of artificial intelligence (AI) in mathematics education in teacher training institutions. Specifically, the study will verify:

1). The prospects of adopting artificial intelligence in teaching and learning mathematics in teacher training institutions.

2). The challenges associated with the adoption of artificial intelligence in teaching and learning mathematics in teacher training institutions.

Research Questions

The following research questions were formulated to direct the study.

1). What are the prospects of artificial intelligence in teaching and learning mathematics in teacher training institutions?

2). What are the challenges associated with the adoption of artificial intelligence in teaching and learning mathematics in teacher training institutions?

Methods

The descriptive survey research design was applied to investigate the prospects and challenges of the adoption of artificial intelligence (AI) in mathematics education in teacher training institutions. The population of the study consists of all the mathematics trainee teachers at Alvan Ikoku Federal University of Education, Owerri. The census sampling technique was adopted in the study as a result of the limited number of trainee teachers in the area. The instrument for data collection was a researcher-made Likert 4-type questionnaire titled "Prospects and Challenges of Artificial Intelligence in Mathematics Education (PCAIME)". The responses ranged from strongly agree (SA), agree (A), disagree (D), and strongly disagree (SD). The validity of the instrument was determined by three experts in mathematics education, robotics education, and measurement and evaluation from the institution. Their expert judgments and recommendations guided the adjustment of the instrument. The instrument was administered to 25 subjects who were not among the sample for the study but had similar characteristics. Cronbach's alpha reliability formula was adopted to determine the reliability of the instrument, which gave a reliability coefficient of 0.80, which was considered adequate for the study. The instrument was administered to the subjects through their various course representatives. The instruments were administered and retrieved on the spot, which enabled a 100% recovery of the instrument. The generated data were analyzed using the mean and standard deviation to answer research questions. Items whose mean responses were within and above the criterion mean of 2.50 were accepted, while those below were rejected.

Results

Research Question 1: What are the prospects of artificial intelligence adoption in teaching and learning mathematics in teacher training institutions?

Table 1: Summary of responses on the prospects of AI adoption in mathematics teaching and learning.

S/N	Item	Mean	SD	Remark
	Prospects of Artificial intelligence adoption in teaching and learning mathematics			
1	It motivates students to learn mathematics.	3.12	0.71	Accept
2	It provides access to teaching and learning materials.	3.10	0.73	Accept
3	It supports personalized learning among students.	2.93	1.04	Accept
4	It provides platform for effective mathematics lecture presentation.	2.64	1.31	Accept
5	It aids development of mathematics problem-solving skills.	2.90	1.00	Accept
6	It provides platform for assessment of learners' mathematics outcomes.	2.85	0.95	Accept
7	It provides tools for research enhancement.	3.15	0.83	Accept
8	It gives immediate feedback on students learning outcome.	2.74	1.12	Accept
9	It provides experiential learning in mathematics.	2.75	1.10	Accept
10	It raises students' learning engagement.	2.88	0.98	Accept
11	It enhances learners' collaboration and interactions.	2.75	1.30	Accept
12	Students learning of mathematics is improved through AI.	2.90	1.00	Accept
13	It enhances augmented teaching.	2.85	1.06	Accept
14	It enhances data-driven insights.	2.81	1.00	Accept
15	It grants scaffolding support to learners	3.00	0.91	Accept
Grand Mean = 2.89 SD = 1.00				

Table 1 revealed that all items were relevant to the research question as such and were accepted as they had response means greater than the criterion mean of 2.50. The implication being that they are all prospects for the adoption for the adoption of artificial intelligence in mathematics education. The grand mean also confirms their acceptance, as it stood at 2.89, which is above the criterion mean, and the standard deviation stood at 1.00.

Research Question 2: What are the challenges associated with the adoption of artificial intelligence in teaching and learning mathematics in teacher training institutions?

Table 2: Summary of responses on the challenges of AI adoption in mathematics teaching and learning.

S/N	Item	Mean	SD	Remark
	Challenges of Adoption of Artificial Intelligence (AI) in Mathematics teaching and learning.			
1	Lack of educators' competence on emerging technologies.	3.05	0.91	Accept
2	Inconsistent power supply in higher institutions	3.11	0.86	Accept
3	Cost of adoption	3.00	0.90	Accept
4	Educators' resistance to change with regards to emerging technologies.	2.85	1.02	Accept
5	Data management system	2.75	1.10	Accept
6	Lack of access to technological facilities	3.13	0.90	Accept
7	Lack of government presence and support towards adoption of technologies.	3.00	0.92	Accept
8	Lack of adequate technical support personnel.	2.95	1.01	Accept
9	Lack of AI awareness among educators.	3.15	0.85	Accept
10	Lack of AI integration into mathematics curriculum	2.74	1.24	Accept
11	Limited access to internet facilities.	3.21	0.82	Accept
12	Content adaptations.	2.84	1.03	Accept
13	Ethical concerns about adoption of AI in mathematics.	2.73	1.12	Accept
	Grand mean = 2.96 SD = 0.96			

Table 2 indicates that all the projected items were accepted as their response means went above the criterion mean of 2.50. Also, the grand mean verifies their acceptance, as it stood at 2.96, which is also above the criterion mean and had a standard deviation of 0.96. Their acceptance indicates that these are the challenges associated with the adoption of artificial intelligence (AI) in mathematics education. **Discussion**

The study investigated the prospects and challenges of the adoption of artificial intelligence in mathematics education. The result of the study revealed that AI has numerous benefits associated with its adoption in mathematics education. The projected items in the questionnaire were all accepted as they had response means greater than the criterion mean. The projected and accepted prospects of AI in mathematics education include: motivation of students, access to teaching and learning materials, support for personalized learning, platforms for effective lecture delivery, development of mathematics problem-solving skills, can be used for assessment of learners, provides tools for research, gives immediate feedback on learning outcomes, provides experiential learning and engagement, grants scaffolding supports, enhances data-driven insight, and augmented learning. This finding is in line with the report of Nwoke et al. (2023), which indicated that the prospects of digital learning technologies in mathematics education include access to virtual manipulatives, collaborative learning, enhanced problem-solving skills, access to mathematics course materials, providing support for individual learners' needs, enhancing creativity, and innovative teaching and learning.

Finally, the result of the study revealed that items on the questionnaire indicating challenges associated with the adoption of artificial intelligence (AI) in mathematics education were all accepted. The items had response means greater than the criterion mean, and the grand mean was also above the criterion mean, verifying the acceptance of the items. This implies the challenges associated with the adoption of AI in mathematics education. They include: lack of educators' competence on emerging technologies; inconsistent power supply in higher

institutions; cost of adoption; educators' resistance to change with regards to emerging technologies; data management system; lack of access to technological facilities; lack of government presence and support towards adoption of technologies; lack of adequate technical support personnel; lack of AI awareness among educators; lack of AI integration into mathematics curriculum; limited access to internet facilities; content adaptations; and ethical concerns about the adoption of AI in mathematics. This result is in consonance with the report of Ogunode et al. (2023), which revealed that poor funding, high cost of artificial intelligence maintenance, high cost of artificial intelligence facilities, unstable internet services, unstable electricity, low level of digital literacy among staff, low level of digital literacy among students, and shortage of artificial intelligence personnel are barriers to effective usage of artificial intelligence in tertiary institutions in North Central Nigeria.

Conclusion

The result of the study revealed that the adoption of artificial intelligence in mathematics education in teacher training institutions offers lots of prospects, including motivation for students, access to teaching and learning materials, support for personalized learning, platforms for effective lecture delivery, and the and the development of mathematics problem-solving skills. The adoption of artificial intelligence in mathematics education outside the prospects has challenges that retard its implementation, which include a lack of educators' competence in emerging technologies, inconsistent power supply in higher institutions, the cost of adoption, educators' resistance to change with regards to emerging technologies, data management systems, a lack of access to technological facilities, a lack of government presence and support towards the adoption of technologies, a lack of adequate technical support personnel, and so on.

Recommendations

Based on the findings of the study, the following recommendations were made:

1). Workshops and conferences should be organized to train mathematics educators on the application of artificial intelligence (AI) tools in teaching and learning.

2). The government should provide technological facilities that will enable educators and students to apply AI to teaching and learning.

3). Alternative power sources should be provided in institutions to enable educators and students to make adequate use of AI tools in teaching and learning.

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