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THE POTENTIAL OF ARTIFICIAL INTELLIGENCE (AI) IN RESPONSES TO TEACHING AND LEARNING OF MATHEMATICS CHALLENGES NIGERIAN SCHOOLS

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Abstract

In mathematics education, many students struggle to learn and retain information, due to the traditional instructional methods being ineffective for all students. Therefore, there is a need for innovative approaches to help students learn and retain information. This paper explores the potential of artificial intelligence (AI) to address the challenges of teaching and learning mathematics in Nigerian schools. AI has the potential to create personalized learning experiences, improve students' engagement and understanding of mathematical concepts, and support teachers in developing appropriate instructional methods. As AI technology continues to advance and become more accessible, its applications in education are likely to become more widespread and effective. The paper also argues that AI has the potential to overcome the limitations of traditional instructional methods, such as the lack of individualized feedback and the inability to tailor the curriculum to the needs of diverse learners. However, the use of AI in education faces several challenges, such as the lack of adequate infrastructure and teacher training. Nonetheless, with proper planning and implementation, AI can revolutionize the way mathematics is taught and learned in Nigerian schools.

[1]

INTRODUCTION

Mathematics is a fundamental subject that is essential for a wide range of professions and industries. In Nigeria, mathematics education has been identified as a key area for improvement, as it has the potential to address several social and economic challenges facing the country. In Nigeria, the importance of mathematics is recognised at the national level, as it is included as a core subject in the country's National Curriculum (Adeeko et al., 2017; Bamidele & Adesina, 2017). However, despite its importance, the state of mathematics education in Nigeria is facing several challenges, including a lack of qualified teachers, inadequate infrastructure and resources, and low levels of student achievement. These challenges are preventing the country from achieving its full potential in terms of economic development and innovation.

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According to the World Bank (2019), Nigeria has one of the lowest rates of trained mathematics teachers in sub-Saharan Africa, with only 30% of teachers in primary and secondary schools having the required qualifications. This lack of qualified teachers is leading to poor quality of instruction, with students often not being able to grasp key mathematical concepts. In addition, many teachers lack the necessary pedagogical skills to effectively teach mathematics, leading to low levels of student achievement. Many schools in Nigeria lack the basic facilities and equipment needed to effectively teach mathematics, such as blackboards, desks, and textbooks. In addition, many schools do not have access to clean water and electricity, making it difficult for students to focus on their studies. Furthermore, the salaries of mathematics teachers are often low, leading to a lack of motivation and high rates of absenteeism.

This lack of adequate infrastructure and resources is hampering the ability of students to learn and achieve their full potential in mathematics. On average, Nigerian students perform significantly below international standards in mathematics, with only 10% of students achieving minimum proficiency levels on international assessments. This lack of achievement is having a negative impact on the country's economy, as it is hindering the development of a skilled workforce that is needed to drive economic growth (Mokoro, 2022). In addition, the low levels of achievement are leading to a lack of interest in mathematics among students, as they do not see its relevance to their future career prospects.

Nigerians are also facing a lack of awareness and support for mathematics education among parents, community members, and policymakers. Many parents do not understand the importance of mathematics education and often do not encourage their children to pursue it as a career path. Additionally, community members often do not provide the necessary support for mathematics education, such as volunteering as tutors or offering scholarships for students. At the policy level, there is a lack of funding and support for mathematics education, as it is often seen as less important than other subjects such as science or language.

Irrespective of these challenges, several opportunities exist to address the challenges facing mathematics education in Nigeria. One such opportunity is the use of artificial intelligence (AI) technologies. AI can help improve teacher training and professional development, improve the quality of instruction, and monitor student progress (Mellor, 2022). AI has the potential to transform mathematics education in Nigeria through its ability to support teacher training and professional development. Online courses and resources powered by AI can help teachers improve their subject knowledge and pedagogical skills. In addition, AI can be used to create personalised learning paths for teachers, based on their individual needs and areas of improvement. This can help to ensure that teachers receive the support they need to be successful in the classroom (Britton & Kumar, 2019). Furthermore, AI can be used to monitor and assess teacher performance, providing feedback and suggestions for improvement.

In terms of the quality of instruction, AI can help to personalize instruction for students, based on their individual needs and learning styles. AI-powered adaptive learning systems can track student progress in real-time, and adjust the learning experience accordingly. This can help to keep students engaged and motivated, while also ensuring that they are mastering key concepts and skills. In addition, AI-powered tools can provide immediate feedback to students, allowing them to self-correct and learn from their mistakes. Furthermore, AI can be used to monitor student progress over time, providing insights into how students are learning and where they might need additional support. This data can then be used to inform policy and resource allocation decisions, ensuring that resources are targeted to areas where they are most needed (Isokpunwu et al., 2022).

For example, AI-generated data could be used to identify schools that are struggling with mathematics instruction and allocate additional resources to those schools. This can help to improve the overall quality of mathematics education in Nigeria, leading to better outcomes for students. Interestingly, AI technology can be used to address

the challenge of low levels of student achievement in mathematics through the assessment of student understanding more accurately and consistently than traditional assessment methods and providing personalized feedback for students based on their individual learning needs. This feedback can be used to help students identify and address their areas of weakness, improving their understanding of mathematics as well as used to motivate and engage students, making learning more enjoyable and effective.

With the right policies and investments, AI could play a transformative role in mathematics education in Nigeria. One important policy change would be to establish national standards for AI-based assessments and feedback systems, to ensure that they are used effectively and ethically. Another policy change could be to require all public schools to use AI-powered learning platforms, to ensure that all students have access to the benefits of AI (Moss, 2021). In terms of investments, the government could allocate funding for the development and implementation of AI systems in schools. These policy changes and investments could be made realistic by starting with a pilot program in a small number of schools. This pilot program could test the effectiveness of AI-based learning platforms and assess the feasibility of implementing them on a larger scale. If the pilot program is successful, the government could then allocate additional funding for expanding the program to more schools.

Furthermore, partnerships could be established with technology companies and universities to develop and implement the necessary AI systems. These partnerships could also help to train teachers on how to use AI effectively in the classroom. The use of AI raises several ethical issues, such as the potential for bias and discrimination, the risk of inaccurate data, and the need for transparency and accountability (Nelson & Molnar, 2020). In terms of privacy, there are concerns about how data collected by AI systems is used and protected. These ethical and privacy concerns will need to be addressed for AI to be used responsibly and effectively in education. The importance of mathematics cannot be overstated. It is a fundamental tool for understanding and describing the natural world, and it is essential for progress in many fields. Despite its importance, the state of mathematics education in Nigeria is facing numerous challenges. This paper therefore explores these challenges and the opportunities presented by AI technology to address them.

Conceptual Clarification

Mathematics Education

Mathematics education can be defined as the teaching and learning of mathematics, to develop students' understanding of mathematical concepts and their ability to apply them in real-world situations (American Educational Research Association, 2022). The goal of mathematics education is not only to develop students' understanding of mathematical concepts but also to develop their ability to apply those concepts in real-world contexts. This involves teaching students how to identify and analyze mathematical problems and use mathematical reasoning and problem-solving skills to find solutions. Students also need to learn how to use mathematics to model and understand real-world phenomena, and to make predictions and decisions based on their mathematical knowledge. This means that mathematics education is not just about memorizing formulas and solving equations, but about developing the ability to think creatively and critically about problems.

Mathematics education is also defined as the process of acquiring mathematical knowledge and skills, and the ability to use these skills to solve problems and make decisions. This definition emphasizes the importance of not only learning the concepts of mathematics but also of being able to apply those concepts in real-world situations. This definition also highlights the importance of developing skills such as problem-solving, critical thinking, and creative thinking, which are all essential for success in mathematics and beyond (Harris, 2014).

Mathematics education is the study of the structure and applications of mathematics, and the teaching and learning of this discipline. This definition emphasizes that mathematics education is not only about the content of mathematics but also about how mathematics is studied and taught (Linder, 2020). This definition also highlights

the importance of understanding the structure of mathematics, and how the different parts of mathematics relate to each other. Understanding this structure can help students to make connections between different concepts and to solve complex problems.

The Nigerian Mathematical Society (2020) defined mathematics education as the development of mathematical knowledge, skills, and understanding through the teaching and learning of mathematics. This definition places a strong emphasis on the development of mathematical skills and understanding, rather than just the acquisition of knowledge. This definition also highlights the importance of mathematics education as a process that is always evolving and changing, as new developments in mathematics take place. In Nigeria, mathematics education plays a crucial role in the country's development, as it is necessary for progress in science, technology, engineering, and mathematics (STEM) fields. Additionally, it is essential for economic development and job creation, as mathematics skills are in high demand in many industries.

Challenges Facing Mathematics Education in Nigeria

There are several challenges facing mathematics education in Nigeria (Uwajumogu, 2016). They include:

Lack of Qualified Mathematics Teachers: refers to the fact that many mathematics teachers in Nigeria do not have the required qualifications, training, or experience to teach mathematics effectively. In some cases, mathematics is taught by teachers who are qualified to teach other subjects, but not mathematics. This lack of qualifications can lead to a lack of understanding of the subject matter and a lack of ability to explain concepts and answer student questions. It can also lead to a lack of enthusiasm and interest in mathematics among students, making it even more difficult for them to learn and progress.

The Lack of Resources and Funding: can be defined as a lack of the financial, physical, and human resources necessary for effective teaching and learning of mathematics. This lack of resources can manifest in several ways, such as a lack of textbooks, supplies, computers, and other teaching materials; a lack of well-equipped and well-maintained classrooms; and a lack of trained and qualified teachers. This lack of resources and funding can have a negative impact on student's learning outcomes and can limit their ability to pursue mathematics-related careers.

Lack of Motivation Among Students: Many students in Nigeria view mathematics as a difficult and uninteresting subject, and as a result, they are not motivated to learn and excel in it. This lack of motivation can be a result of several factors, including the negative attitudes of parents and teachers towards mathematics, the low status of mathematics in society, and the difficulty of the subject. This lack of motivation can lead to poor learning outcomes and can prevent students from pursuing careers in mathematics and related fields.

The Negative Attitude of Parents and Society Towards Mathematics: Many parents and members of society view mathematics as a difficult and unimportant subject, and as a result, they do not encourage their children to pursue it. This negative attitude can be seen in the way that mathematics is portrayed in the media and in popular culture, as well as in the way that it is taught in schools. This negative attitude can have a negative impact on students' motivation and can prevent them from pursuing mathematics-related careers.

Limited Opportunities for Mathematics Students in Nigeria: There are few opportunities for mathematics students to pursue higher education and find employment in mathematics-related fields. This lack of opportunities can lead to low levels of interest in mathematics among students and can prevent them from reaching their full potential (Okoye, 2019).

AI Technologies

AI technologies can be defined as computer systems that can perform tasks that would typically require human intelligence, such as understanding natural language, learning from experience, and making decisions (American Psychological Association, 2020). These technologies are based on the principles of artificial intelligence, such as machine learning, natural language processing, and computer vision. They are being used in a variety of

applications, including healthcare, finance, transportation, and education. One such application is in the field of mathematics education. In the context of this paper, the focus is the use of intelligent tutoring systems (ITS) in mathematics education. ITS are computer-based systems that provide adaptive learning experiences to students, based on their individual needs and abilities. They use a combination of artificial intelligence techniques, such as natural language processing and machine learning, to provide personalized learning experiences to students. For example, an ITS for algebra might adapt the questions it asks based on the student's previous answers and might provide explanations tailored to the student's level of understanding (Pujol et al., 2021).

A more detailed definition of ITS is that the ITS are interactive, computer-based systems that are designed to provide individualized instruction and feedback to students. They use a variety of techniques, such as natural language processing, machine learning, and cognitive science, to create a personalized learning experience for each student. ITS are interactive, computer-based systems that are designed to provide individualized instruction and feedback to students. They use a variety of techniques, such as natural language processing, machine learning, and cognitive science, to create a personalized learning experience for each student (Powell, 2022). ITS can be used for a wide range of topics, including algebra, geometry, and calculus. They can also be used to supplement traditional classroom instruction, or they can be used as standalone tools for self-study.

The ITS component and how it works (Powell, 2022):

The first component of an ITS is the knowledge base, which contains the domain knowledge, or the mathematical concepts that the system is designed to teach. The knowledge base can be very large and may contain a variety of resources, such as examples, practice problems, and step-by-step solutions.

The second component is the student model, which is a representation of the student's knowledge and skills, based on their previous interactions with the system. The student model is used to determine what content to present to the student and how to adapt the instruction to meet their needs.

The third component of an ITS is the pedagogical model, which is the system's approach to teaching and learning. This model determines how the knowledge base and student model are used to create a personalized learning experience for the student. The pedagogical model is usually based on principles from cognitive science, such as scaffolding, feedback, and reinforcement. It might include strategies such as providing hints and worked examples, or using repetition and spaced repetition to aid in learning.

The fourth component is the user interface, which is the interface that the student interacts with. This interface can be text-based, graphical, or a combination of both.

The fifth component is the assessment engine, which is used to evaluate the student's performance and progress. This component may use techniques such as item response theory, Bayesian inference, or other statistical methods to determine the student's level of understanding.

Finally, the sixth component is the tutor agent, which is the part of the system that interacts with the student. This agent can be designed to have a personality, or it can be more neutral and objective. Some ITS have been designed to be very interactive and conversational, while others are more straightforward and task-oriented.

The main benefits of ITS are that they can provide personalized instruction, which is tailored to each student's individual needs and abilities (Powell, 2022). This personalization can lead to improved learning outcomes, as students are more likely to remain engaged and motivated when they are learning at their own pace and level. The personalization provided by an ITS can have several other benefits in addition to improved learning outcomes. First, it can help to create a more equitable learning environment, as students with different levels of ability can be accommodated. Second, it can increase student engagement and motivation, as students are more likely to stay interested in the material if it is presented in a way that is tailored to their individual needs. Third, personalized

instruction can help to increase student confidence, as they will be able to see their progress and feel a sense of accomplishment (Powell, 2022).

In addition, ITS can provide instant feedback, which can help students correct their mistakes and understand the material more deeply. The instant feedback provided by an ITS can be very valuable for learning mathematics. In traditional classroom settings, a student may not receive feedback on their work until days or even weeks after they complete it. By that time, they may have forgotten the details of the problem and the steps they took to solve it. With an ITS, a student can receive immediate feedback on their work, allowing them to correct their mistakes and solidify their understanding of the material. Instant feedback can also give students a sense of progress and accomplishment, which can increase their motivation to continue learning.

Finally, ITS can help to reduce the workload of teachers, as the system can take on some of the tasks that would normally be done by a human teacher. One way that an ITS can reduce the workload of teachers is by providing formative assessment and feedback. In a traditional classroom, a teacher may need to manually grade each student's work and provide individualized feedback. This can be a very time-consuming process. An ITS can automate this process, freeing up the teacher to focus on other tasks, such as planning lessons or meeting with students one-on-one. In addition, an ITS can provide feedback to students that is tailored to their level of understanding, which can be difficult for a teacher to do with a large class of students (Powell, 2022).

The Potential Benefits of AI Technologies for Mathematics Education

AI technologies can and should be used to improve mathematics education, for several reasons (Powell, 2022):

Increased Student Engagement: can be defined as a student's willingness and ability to be actively involved in the learning process. It includes both cognitive and behavioural aspects, such as paying attention, participating in discussions, asking questions, and seeking feedback. Research has shown that increased student engagement can lead to improved learning outcomes in mathematics, as it allows students to process information more deeply, retain information better, and develop a stronger understanding of concepts. For teachers, increased student engagement can help to create a more positive and supportive learning environment, and can make teaching more rewarding and satisfying.

Personalised Learning: can be defined as a learning approach that tailors instruction to the individual needs, abilities, and interests of each student. In the context of mathematics education, personalized learning can involve providing individualized instruction, using learning materials that are matched to each student's level of understanding, and using adaptive technology that responds to each student's performance. This approach can lead to improved learning outcomes, as it allows students to learn at their own pace, in a way that is most effective for them. For teachers, personalized learning can provide valuable insights into each student's strengths and weaknesses, and can allow them to tailor their teaching strategies accordingly.

Improved Outcomes in Mathematics Education: can be defined as the measurable improvements in student learning that result from effective teaching and learning strategies. These outcomes can include increased test scores, improved problem-solving skills, better understanding of concepts, and increased confidence in mathematics. For teachers, improved outcomes can lead to greater job satisfaction and a sense of accomplishment. For students, improved outcomes can lead to increased academic success, higher achievement in mathematics, and improved career prospects.

Real-time Feedback and Support for Students: This can be defined as providing immediate, personalized feedback and assistance while students are engaged in the learning process. This can include feedback on homework assignments, guidance on problem-solving strategies, and support for overcoming difficulties. For students, this type of support can lead to improved learning outcomes, as it can help them identify areas of weakness, correct mistakes, and develop strategies for success. For teachers, providing real-time feedback and

support can allow them to adapt their teaching in response to student needs, and can help them to identify and address misconceptions and difficulties promptly.

Automation of Certain Tasks in Mathematics Education: can be defined as the use of technology to reduce the workload of teachers, by automating repetitive and time-consuming tasks, such as grading, recording grades, and generating reports. This can allow teachers to focus their time and energy on more important tasks, such as planning lessons, providing personalized instruction, and addressing student needs. For students, this can result in improved learning outcomes, as it can allow for more individualized and effective instruction.

Creating Adaptive Learning Environments: An adaptive learning environment adapts to the individual needs of each student, based on data gathered from the student's interactions with the learning system (Li et al., 2021). In the context of mathematics education, an adaptive learning environment might adjust the difficulty level of a lesson based on the student's previous performance, or it might provide additional support if the student is struggling with a particular concept. The goal of an adaptive learning environment is to maximize the learning experience for each student, by providing the right level of challenge and support. For students, this can lead to improved learning outcomes, as the learning experience is tailored to their individual needs.

CONCLUSION

The study concluded that the use of AI in mathematics education has the potential to address many of the challenges facing schools in Nigeria. AI has the potential to lead to improved learning outcomes for students, teacher workload, and satisfaction as well as can lead to a more equitable learning experience for students since it can adapt to individual needs and abilities. It is important to note that the successful implementation of AI in mathematics education will require careful planning, ongoing support from educators, and a commitment to ongoing professional development. However, despite the challenges and considerations involved in AI for both students and teachers, it is an area that deserves further exploration and investment.

Suggestions

To implement these suggestions, it will be important for the Nigerian government to invest in the development and deployment of AI technology in schools. This can be done through the following initiatives:

- Providing funding for the development and implementation of AI-based tools for teachers and students.
- Developing a national strategy for the adoption of AI in education, with clear goals and timelines.
- Partnering with technology companies and educational institutions to develop and pilot AI-based solutions in select schools.
- Establishing teacher training programs that focus on the use of AI in the classroom.
- Providing incentives for schools to adopt

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