Challenges and Prospects of Integrating Artificial Intelligence (AI) into Mathematics Classroom

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Abstract

This paper investigates the challenges and prospects of integrating Artificial Intelligence (AI) into mathematics classrooms, particularly within the Nigerian educational context. The widespread adoption of AI technologies presents both opportunities for enhanced learning experiences and significant hurdles in implementation. The research problem addresses how AI can be effectively leveraged in mathematics education in Nigeria, considering existing infrastructure, teacher preparedness, and pedagogical implications. Despite significant technological advancement, the Nigerian educational system is yet to integrate AI into classroom instruction, creating a gap that this examined. Employing a qualitative literature review, this paper synthesizes findings from eleven recent studies, identifying the benefits of AI such as personalized learning and real-time feedback, alongside barriers including limited infrastructure, teacher preparedness, and data privacy concerns. Insights suggest that while significant challenges exist, the integration of AI holds immense promise for personalized learning, accurate feedback, and increased student engagement in mathematics. The study concludes by emphasizing the need for strategic planning, investment in infrastructure, and teacher training to ensure effective adoption. The study offered a framework for stakeholders to navigate the transition toward AI-enhanced mathematics education.

Introduction

Artificial Intelligence (AI), often defined as intelligent machines or systems capable of performing tasks that typically require human intelligence, such as recognizing speech, understanding natural language, and making decisions, is rapidly transforming various sectors globally. In the context of education, AI presents transformative opportunities, particularly in mathematics instruction, through applications like Intelligent Tutoring Systems, AI-powered assessment tools, and adaptive learning platforms.

Mathematics, as a foundation for scientific, technological, and economic development, plays a pivotal role in the educational process (Institute of Mathematics, 2022). Yet in Nigeria, challenges such as poor student performance, lack of motivation, and limited resources persist. These problems are exacerbated by a lack of effective instructional tools. The emergence of AI offers a promising solution by personalizing learning, providing timely feedback, and increasing student engagement.

However, the implementation of AI in Nigerian classrooms faces significant hurdles. Many schools lack the necessary infrastructure, and teachers often have limited awareness or training in AI applications. Additionally, concerns around data privacy, ethical use, and the fear of AI replacing human teachers further complicate the adoption process.

This paper investigates how AI can be effectively integrated into mathematics education in Nigeria amidst these constraints. The study adopts a qualitative literature review method to assess existing research findings, identify patterns, and draw conclusions that inform policy, training, and classroom practice. The ultimate goal is to offer feasible pathways for integrating AI in a way that supports, rather than disrupts, educational goals.

The sections that follow provide a detailed analysis of technology in mathematics education, conceptual understanding of AI, implications for mathematics classrooms, existing AI tools, identified challenges, potential prospects, and recommendations for stakeholders.

Technology in Mathematics Education

Educational technology is defined through a variety of electronic tools and applications that help deliver learning materials and support learning processes in education to improve academic learning goals (Cheung &Salvin, 2011). Common examples include Computer-Assisted Instruction (CAI), Integrated Learning Systems (ILS), Video and Audio media, and interactive white boards. The utilization of these educational resources plays important roles in the achievement of educational objectives and goals (Itodo, 2021). The extent to which an educational institution obtains her objectives is related to the educational resources utilized in facilitating the teaching and learning process. Technology as a resource in education dates back to the 1950s with the introduction of computer-assisted instruction (Chan, 2023). In mathematics, it has evolved to include advanced tools like geometer's sketchpad (https://sketchpad.keycurriculum.com) or Tinkerplots (https://www.tinkerplots.com).

The impact of the Covid 19 pandemic on education has highlighted disparities in the preparedness and utilization of digital tools among schools and families for online learning. While teachers and students have shown increased proficiency in using technology for general tasks like meetings and presentations, the adoption of digital technologies for mathematical exploration and analysis has not seen similar advancement. This underscores the need for further development and integration of digital tools to support education effectively, ensuring alignment with future needs and equitable access for all learners.

Making technology positively contribute to the teaching and learning process of mathematics that includes formal and informal use of ICTs, in the classroom by students and teachers will require integrating a new advancement that encompasses a number of dynamic factors, effective practices, technological aspects of new tools, with potential to transform learning as well as enabling new forms of teaching and learning practices. Such an upgrade should be able to transverse the technical, social and informational aspects of teaching and learning mathematics respectively and together. So, the question is no longer whether teachers should use educational technology applications or not, but rather how best to incorporate new and advanced educational technology applications into classroom settings (Cheung &Slavin, 2011).This quest for the best technological option for the mathematics classroom points to the idea of Artificial Intelligence (AI).

Concept of Artificial Intelligence (AI)

Artificial intelligence simply means intelligent machines or systems. These systems are considered intelligent for efficiently performing tasks that would normally require human intelligence, such as recognizing speech, understanding natural language, and making decisions based on complex data (Baker & Smith, 2019). It is a field that encompasses machine learning as well as other approaches to structure smart systems used in a wide variety of applications, creating systems with advanced understanding of natural language or images, which require complex internal rules beyond manual design capabilities. To address this complexity, an automated design process known as machine learning is utilized. Machine learning (ML) is a subfield of artificial intelligence that focuses on learning from examples to develop internal representations enabling the system's output to align with the provided examples. In ML, practical instances of concepts or behaviours are used to train the system, allowing it to autonomously improve their performance over time by adapting to new data and scenarios. Machine learning as articulated by Mitchell (1997) focuses on developing computer programs that enhance their performance autonomously through experience. Mitchell's perspective emphasizes three key characteristics of ML systems: automated learning without human intervention, measurable performance for improvement assessment and learning based on receiving examples. A well-designed ML system ensures performance enhancement as it processes more examples, reflecting a continuous aptitude for advancement in computational capabilities through experiential learning. The construction of computer programs that improve automatically with experience has roots dating back to the early days of artificial intelligence, notable in Alan Turing's vision in the mid-19th century. However, a foundational framework for machine learning was solidified by Vladimir Vapnik in 1995 through his ground-breaking work on statistical learning theory, marking a significant advancement in the field's theoretical underpinnings and practical applications (Vaerenbergh& Perez-Suay, 2021). During the evolution of machine learning, neural networks and support vector machines gained popularity for real-world applications, though initially limited to simpler tasks compared to modern standards. Significant advancement occurred around 2010 when neural networks demonstrated the capability to tackle more complex tasks by scaling them up and providing them with a larger volume of training examples, marking a pivotal moment in the history of machine learning. This development paved way for the emergence of deep learning, enabling the successful application of artificial intelligence in various domains such as image and voice recognition, and neural language understanding.

Technology has infiltrated into every aspect of modern life and schools are no exception. Teachers are now more exposed to the use of educational technology, which is also now more affordable compared to some decades ago and technology will continue to play increasingly important roles in the future of educational institutions. Following the endorsement by The National Council of Teachers of Mathematics (2011) on the use of educational technology in mathematics education stating that, "Technology is essential in teaching and learning of mathematics; it influences the mathematics that is taught and enhances students' learning." Educational technology is making a modest difference in learning of mathematics. It is a support, yet not a breakthrough. However, the evidence to date does not show satisfaction but rather projects that new and better tools are needed to harness the power of technology to enhance mathematics achievement for all.

Gresalfi (2013) assessed how different types of technology can enhance student involvement in learning mathematics. Gresalfi focused on the capabilities of technology engaging students in specific ways, the framework aimed at analysing learning interactions with extensive data and make informed assessments about the effectiveness of various technologies in promoting meaningful engagement with mathematics. The author opines that this approach helps in documenting learning experiences and forming hypotheses regarding the impact of technology on enhancing students' engagement and learning outcomes in mathematics education. Greeno and Gresalfi (2008), discussed learning opportunities as a set of affordances for learning, inspired by Gibson's theory of perceptual affordances. They highlighted that human activity involves the environment offering actions, the individual's intention to engage with those actions, and the individual's ability to carry out those actions (Martinez & Castro, 2013). This perspective emphasizes the dynamic interaction between the environment, individual intentions, and capabilities in the learning process. Their views relate how technologies provide unique affordances that can either enhance or hinder deeper engagement in educational settings. Tools like geometer's sketchpad, Tinkerplots, and others like games may not only facilitate productive engagement with mathematical concepts but also offer a playful environment that may divert students from focusing on essential ideas. This emphasizes the importance of designing technology-enhanced learning experiences that encourage critical engagement with content while considering the potential distractions that certain tools may introduce. Thus, by analysing the affordances of tasks, technology or design decision, and educators can make informed conjectures about student actions, through data collection and analysis of student participation, gaps may be identified and appropriately addressed and learning outcomes can be achieved or improved.

The World Economic Forum's report (2018) emphasized the strategic significance of adjusting educational curricula with the realities of the contemporary career opportunities, where proficiency in AI is increasingly valued.

Golding and Lyakhova (2021) reported that, the integration of digital technologies in mathematics education is reshaping traditional student-teacher dynamics and erasing boundaries between in-school and beyond-school learning environments. Adding that, the Covid-19 pandemic has highlighted the crucial role of technology in crisis situations, prompting a global re-evaluation of the applications of digital tools in mathematics education. On the on-going evolution and importance of digital technologies in shaping the future of mathematics education, they portrayed the importance of understanding concepts and processes in mathematics by the utilization of both traditional and digital approaches, which can complement each other, and in so doing, play a significant role in facilitating connection-making in mathematics both inside and outside the classroom, aimed at enhancing conceptual exploration and providing immediate feedback to support learning.

Vaerenberg and Perez-Suay (2021), provide an overview of the different AI systems that are being used in contemporary digital tools for mathematics education. They established a catalogue of four classes as information extractors, reasoning engines, explainers, and data-driven modelling techniques used to extract useful information from student-generated data. They demonstrated the integration of AI technologies in education setting by linking this catalogue to various mechanisms in modern digital mathematics education tools to enhance learning experiences. Secondly, they highlighted the interconnectedness between research in AI and mathematics education with the adaptation of AI techniques initially designed for other fields, to enhance mathematics education through current research trends and suggested the emergence of standard AI-based applications for mathematics education in the future.

Remarkably, Hwang and Tu (2021) gain a broad picture of the research inclinations of AI in mathematics education. They searched for relevant articles in the field of education and mathematics education focused on the application of AI using keywords that related to AI and mathematics education and found a total of 136 articles with 43 of them meeting the criteria after manual review for content relevance and quality. The selected articles specifically addressed the use of AI in practical mathematics learning activities, setting the stage for further analysis through bibliometric mapping. Their analysis of articles on AI in mathematics education from 1996 – 2020 also revealed the predominant use of traditional machine learning methods over modern AI approaches like deep learning in developing Intelligent Tutoring Systems (ITS), they revealed that, focus on evaluating students' statuses and achievement was placed particularly on cognitive and affective dimensions. Following these findings, Hwang and Tu promoted the integration of AI technologies, such as personalised guidance systems and adaptive learning environments, to improve learning outcomes and address challenges in mathematics education.

More fascinating, in 2022, Lee and Perret (2022) pointed out that, innovative STEM curriculum and professional development workshops for integrating AI methods into STEM classroom will equip high school teachers with AI knowledge and provide hand-on activities to enhance engagement. They submitted that, curriculum supported by prior work and inclusion of interactive tools facilitated teachers' understanding of AI concepts and application in their disciplinary classrooms. However, warning that, the support provided should not be uniformly equal for all teachers, particularly for educators lacking a strong background in the interlinings of digital technologies.

Viberg, Grönlund and Andersson (2023) revealed that digital tools in combination with sound pedagogy has the potential to facilitate broad critical thinking and problem solving as well as the development of capacity to facilitate realistic problem solving and collaborative approaches to teaching and learning of mathematics. While many scholars have promoted the potential of ICTs in combination with appropriate pedagogy to support teaching and learning of mathematics, some studies like Martinez & Castro (2013); Konijn & Hoorn (2020);

Chichekian and Benteux (2022); about the use of digital technology in mathematics education stress that technology in the classroom does not primarily live up to perceived potential of transforming the learning experience with claims that student engage in formal use of digital technologies less often than informal uses which enhance traditional practices rather than educational contexts.

Wardat, Tashtoush, Al Ali, and Saleh (2024), investigated mathematics teachers' perceptions of implemented AI systems and applications in Abu Dhabi Emirate Schools using a sample made up of 580 male and female mathematics teachers from public and private schools across three educational regions in Abu Dhabi selected based on several qualifications and experiences. Their findings reveal that AI could be used as an educational tool to facilitate teaching and develop students' performance by including AI systems and applications in mathematics curricula. The results also showed that mathematics teachers face grave challenges in applying AI systems and applications, the most prominent of which is the need to exert more effort than the traditional method when using different AI system and applications adding that the pressures placed on them prevent them from using AI in Teaching. Notably the findings showed no statistically significant differences in mathematics teachers' perspectives regarding the importance of using systems and applications of AI in teaching; yet, statistically significant differences were found in mathematics teachers' challenges when applying AI systems and applications in teaching according to their educational qualifications, with emphasis among mathematics teachers who have masters' degrees. Such studies are foundational guidelines for future integration of AI into mathematics classroom as it reports teachers' experiences in utilizing AI systems and various considerations regarding its implementation.

Artificial Intelligence and Mathematics Education

Artificial intelligence (AI) holds a long historical development from philosophical observations to a formal science, requiring advancements in mathematical formalization of logic, computation, and probability theory such that a reciprocal relationship with mathematics seems to emerge, where AI contributes to mathematical fields through various applications, showcasing the symbiotic nature of their interaction in advancing both disciplines (Vaerenbergh & Perez-Suay, 2021). Some parallels between both fields includes their intimacy with construction of sound reasoning based on the use of logic; while the goal of Mathematics education is developing mathematical reasoning skills, AI systems are designed to perform reasoning tasks in an automated manner. Also, modern AI techniques involve impressions of teaching and learning. Some AI systems are designed to learn models and concepts in an independent manner or supervised through some form of Instruction, mirroring the educational goal of developing reasoning skills in humans. However, irrespective of these parallels, humans and machine differ in their capacities and approaches of carrying out tasks(Vaerenbergh & Perez-Suay, 2021).It is therefore dangerous to generalize compasses of machine behaviour to human performance. In the context of artificial intelligence (AI), the overarching goal is to develop machine capable of solving complex problems that may challenge human perception of difficulty. These problems can range from tasks involving intricate thought processes and reasoning abilities to exhibiting behaviours that are perceived as intelligent. AI aims to bridge the gap between human cognitive capabilities and machine performance by creating system that can tackle such challenging tasks effectively.

AI and its applications are been used in different areas of life and have taken vital roles in improving efficacy and effectiveness through the development of computer systems, to operate with superior efficiency similar to the efficiency of an expert human being. AI has become an applied science revolving the day-to-day activities affecting humans' present and future reality with incredible technical advancements (Mahmoud, 2020). AI plays a crucial part in many sensitive fields like medical, legal, education, and also security and military fields. AI can conduct scientific research and provide easy access to more discoveries (Abdelnour, 2004).For Mathematics, Jauhiainen and Garagorry (2023) showed the positive impact AI tools or applications exhibited in enhancing students' understanding of mathematical concepts through the utilization of mobile applications, educational games, interactive systems, lesson design tools in customizing educational materials and creating tailored educational experiences, and using student data analysis and automatic recommendations in teaching and learning of mathematics

Using AI systems in teaching does not come easy, starting with the difficulties of using technical applications, which require more time and effort compared to traditional methods, obtaining the updated versions and anti-virus programs, navigating the scarcity of specialists and experts, and the lack of training programs and awareness courses paint a rigorous exercise (Jauhiainen & Garagorry, 2023). Despite this, Nguyen (2023) identified some benefits of using AI tools to include the following:

i. **Customized learning:** AI tools help personalize education and meet students' needs better by providing suitable content for each student's level

ii. **Accurate feedback:** can offer precise assessments of students' performance and immediate feedback, contributing to improved learning periods.

iii. **Increased engagement:** achieved when educational games and interactive activities can capture students' interest and increase their participation.

AI Tools for Mathematics Learners

At present, AI-based tools for mathematics education are:

a. **Photomath** (https://photomath.app): A new breed of calculators known as photomath gained popularity among schoolchildren in 2014, this app allows users to point their phone camera at equations in textbooks to obtain instant solutions, including detailed reasoning steps, and later versions even recognize handwritten equations. The emergence of such "camera calculators" is attributed to advancement in image recognition technology, particularly Optical Character Recognition (OCR) algorithms based on deep learning, enabling the automation of mathematical problem-solving processes. The OCR algorithm converts a mathematical equation from an image; standard equation solvers are utilized to derive a solution. The final stage involves explaining the solution to the user through a sequence of steps with algorithmic resolution for tasks like solving linear equations that require minimal artificial intelligence intervention. For an AI system to find shorter or more intuitive solution in mathematics, it would need the ability to mimic human intuition or explore creative problem-solving strategies. This requirement goes beyond standard algorithmic approaches and involves developing models that can replicate human-like decision-making processes and innovative thinking methods. Achieving this level of AI capacity would enhance the system's problem-solving efficiency and effectiveness in mathematical tasks. Several other apps have followed suit like Google's Socratic (https://socratic.org) and Microsoft Math Solver (https://microsoft.com). The emergence of advance calculators such as photomath, Google's Socratic, and Microsoft Math Solver, has sparked a renewed debate on the proper integration of technology in mathematics education. This resurgence of discussion mirrors the historical controversy surrounding the introduction of pocket calculators into education decades ago. These new tools represent a shift towards smarter calculators that streamline the problem-solving processes, raising questions about the balance between technological assistance and the development of mathematical skills in students (Webel & Otten, 2015).

b. **GeoGebra** (https://www.geogebra.org): Dynamic Geometry Software (DGS) for all levels of education that brings together geometry, algebra, spread sheets, graphing, statistics and calculus in one engine. GeoGebra offers an online platform with over 1 million free classroom resources shared through a collaborative platform where student progress can be monitored in real time. GoeGebra has evolved to include automated reasoning tools that enable rigorous mathematical verification and automatic discovery of general propositions related to Euclidean geometry figure created by users. These tools go beyond traditional calculators by automating the reasoning process to some extent, allowing for more sophisticated exploration and analysis of geometric concepts within the software. This advancement signifies a shift towards enhancing mathematical understanding and problem-solving capabilities through technology in the field of geometry education (Kovács et al, 2020). In 2021, GeoGebra became part of the BYJU's (http://https//www.byjuslearning.com/en-US/about-us/meet-byju/) family with millions of students on their learning platforms. GeoGebra continues to operate as an independent unit.

c. **Intelligent Tutoring System(ITS):** A system that imitates human tutors and aims to provide immediate and customized instruction or feedback to learners, usually without requiring intervention from a human teacher. Vaerenbergh and Perez-Suay (2021) described a hypothetical scenario where a student interacted with an intelligent tutoring system for learning mathematics, the system monitors the student's progress, provides hints and feedback, personalizes the learning path based on the student's interactions, and offers tailored support to enhance the learning experience. This example illustrates the application of data-driven AI techniques in educational technology to improve mathematics education through personalized and interactive learning experiences. Graesser et al (2012) pointed that, while sharing some technological foundations with AI-based calculators, ITSs are more intricate and interactive tools offering comprehensive reviews and discussion of their functionalities, processes and capabilities within educational settings.

d. **Information extractors**: This refers to AI technologies that convert real world observations into mathematical representations. A classic example involves parsing the text of algebraic word problems to generate corresponding equations (Koncel-kedziorski, 2015). This technique showcases how AI can transform unstructured data into structured mathematical information, demonstrating the potential of AI in information extraction tasks.

A camera calculator utilizes this technique to translate visual data into mathematical representations. Camera calculators like Socratic can capture images of real word problems, convert them into text, interpret the content, and then transform the text into mathematical representation. This process involves sophisticated information extractors that utilize Convolutional Neural Networks (CNNs), a specialized type of artificial neural network designed to process spatial information found in pixel neighbourhood by using digital filters. It is effective in tasks like Object recognition, image classification, and computer vision applications (Krizhevsky et al., 2012).

e. **Reasoning engines**: In the context of mathematics education, a reasoning engine is defined as a computer program capable of automatically solving mathematically formulated problems by inferring logical consequences from a set of axioms and predefined rules (Furht, 2008). This broader definition encompasses various software systems. More advanced reasoning engines, such as Automated Theorem Provers, aim to verify and generate proofs of mathematical theorems, requiring complex processes like proof generation. Proof verification involves checking the correctness of each step in a proof, which is a straightforward process. On the other hand, proof generation is more challenging as it requires navigating through a vast number of possible steps in the proof sequence. A significant advance in reasoning engines is the integration of machine learning, particularly deep learning where ML algorithms learn from training examples to create data-driven models without explicit programming of rule or logic. Researchers are exploring methods to automate abstract reasoning processes, such as explaining cause-and-effect relationships statistically, indicating a shift towards developing AI system capable of advanced cognitive tasks beyond traditional pattern recognition(Pearl & Jewell, 2019).

f. **Explainers:** These are AI techniques employed to generate interpretable solutions, particularly in educational settings where understanding the rationale behind proof is essential. Reasoning engines alone may not always provide understandable proofs, especially in contexts like mathematical education where clarity and interpretability are crucial for the learners to comprehend the reasoning behind the proofs in producing human-readable results (Ganesalingam & Gowers, 2017). Explainers aims to bridge the gap between the complex, opaque nature of modern AI algorithms and the necessity for clear, understandable explanations in decision-making processes involving sensitive data. In the field of mathematics education, explainers will be responsible for step-by-step explanations to an equation’s solution.

g. **Data-driven modelling:** These techniques involve extracting and analysing substantial amounts of data to generate perceptions, insights and practical models, ultimately enhancing the learning process for individual, and or group of students. Thus, by employing data mining and machine learning methods, AI systems can convert real-world and sensor observations into numerical representations, leading to the development of data-driven models that improve educational outcomes. Such models can be utilized in mathematics education to predict a student's performance and identify the specific step at which a student or group of students comprehends a concept (Smith et al, 2015; Asif et al, 2017).

Approaches for Integrating AI in Mathematics Classroom

The consolidation of AI methods and tools leverage both learning and teaching, the engagement of artificial intelligence seems to be a must to deliver a competitive environment. Narrowing these to the mathematics classroom, the main problems are related to content flexibility and adaptability, and for reusability, sharing and collaborative development of the learning objects and structures (Owoc, Sawicka & Weichbroth, 2021). Evolutions and advancement are ongoing in the field of artificial intelligence and as mathematicians will agree, it's mostly when problems are encountered, uncovered and analyzed logically, reasonably and practically that solutions are proffered. AI in the mathematics classroom is a powerful tool for the human teacher to generate access, comprehend and structure new knowledge at very fast, objective, subjective, and collaborative pace. For the learners it is in general a big sigh of relief in terms of meaningful learning and personal development in mathematics knowledge and realities and a path to lifelong success.

There are several approaches to planning and organizing the implementation of AI methods in the education domain noted by Owoc et al (2021), the list of potential challenges that influence the implementation concerns:

a. **Strategy** refers to a general plan of implementation to achieve one or more specific long-term goals accordingly to a schedule established and agreed with all interested stakeholders; as one would expect, it is important to establish a strategy that defines the goals with regard to the AI implementation and provides a means to manage them. The strategy itself might take the form of a mix of qualitative and quantitative approaches. The former aims to describe how the goals will be fulfilled, while the latter aims to decide if the goals are fulfilled and which goals are fulfilled. The fulfillment of the goals can be expressed in designing curriculum modules flexible with intelligent machines or platforms.

b. **Institutional maturity** refers to its employees, processes and technology keenness and capability with respect to the adoption of artificial intelligence technologies. In general, maturity is a synonym of 'full development' or "perfected condition," and since any institution is a living entity, it grows over a period of time and learns from its decisions and outcomes. Therefore, all institutions seem to be at some stage of maturity, striving forward to development and perfection. From a strategic point of view, importance is placed on the high level of educational institution maturity due to the changes spanning across core dimensions of strategic management such as: alignment, performance measurement and management, process improvement and sustainability. In the context of this paper, maturity assessment should encompass external and internal benchmarks, describing the organization readiness and capability to adopt AI technologies.

c. **Data governance**, refers to data principles, quality, meta-data, access requirements and data life cycle; since machines learn on the basis of data, data governance is a crucial facet of the implementation and further maintenance of AI related to the system of data organization, collection, control, storage, usage, archival and destruction. The path of setting up data governance is driven by a specific program, supported by particular policies and procedures, and communicated by Institutional leadership and management. In general, the regulations must provide all of the necessary means to preserve the following generic requirements: accessibility, availability, completeness, accuracy, integrity, consistency, auditability, and security.

d. **Infrastructure**, being the combination of hardware and software systems, is particularly critical due to compatibility and integration issues. The specific requirements toward hardware capacity and software capabilities. In an effort to integrate these cutting-edge technologies with the existing systems, one has to incorporate solutions that underpin a flexible and scalable end-to-end integration for implementing new and updating existing technological applications from a catalog of services.

Challenges of Integrating Artificial Intelligence into the Mathematics Classroom

a. Limited Creativity

Creativity is considered a human trait that AI does not have and this poses a challenge for guidance of student learning especially in mathematics education. Students learn in diverse ways and it takes an intelligent and creative minded tutor to interact with such students, understand their unique and general challenges, then come up with required strategies and method of guiding and teaching theses students in order to create meaningful learning and facilitate their understanding of mathematics concepts.

b. The Right Model for Mathematics Education

AI is expected to exhibit a fair amount of generalization in order to be effective in managing the mathematics classroom. This is essential for adapting to diverse situations beyond their initial training data by transferring learned concepts to new contexts that will require the possession of general knowledge across various domains. More insights from cognitive and developmental psychology to comprehend student behaviors accurately, which poses a significant challenge for current machining learning research is vital as it is currently limited. The COVID 19 pandemic have widely shown that technology can be deployed which is good but more problematic is the worrisome impact on social, cultural and emotional dynamics of teacher-student interactions on holistic outcomes from both teaching and learning angles. Personally, during the shut-down of face-to-face school interactions, while students who could not afford to take online classes were anxious to get back to school again, the others who enjoyed online classes soon got tired of the social disconnect and longed for a little bit of the traditional face to face environment.

c. AI Replacing the Human Teacher

Accompanying the growing development and implementation of AI in education are emerging concerns on the potential for AI to wholly replace teachers with arguments that AI is better equipped than human educators to deliver standardized content, assessments, and can work tirelessly without fatigue or bias. Others oppose with arguments that AI lacks the empathy and emotional intelligence necessary for effective teaching and learning (Chan &Tsi, 2023).

Another reviewed study by Melchor, Lomibao, and Parcutilo (2023),explored the potential of AI integration in mathematics education for generation alpha, they indicated challenges like infrastructure limitations and data privacy concerns, biased responses. One key point to note in their study was the proposition that, to successfully integrate AI into the Philippine education system, it is crucial for an examination of factors that led to crisis experienced by many tertiary schools during the transition from traditional to online learning amid the covid-19 pandemic. This is a very sensitive area to explore when considering issues of AI's potential to replace human teachers. On the other hand, Wardat et al (2024) argued that, maths teachers face grave challenges in applying AI systems and applications, for them using these applications in class requires more effort, and the pressures placed on them coupled with inadequate digital competence, poor infrastructure and the fear of losing their jobs prevent them from using AI in Teaching.

d. Future Challenges Perceived

The CEO of Fusemachine, Sameer Maskey, argued that the application of machines in learning environments is only one variable in a multifaceted equation, where if the spread of this resource is not uniformly distributed becomes a challenge in measuring or generalizing impact. Furthermore, Lee and Perret (2022) report on the non-uniformity and inequality of the support provided particularly for educators lacking a strong background in the interlinings of digital technologies. This in line with the unequal distribution of digital resources and infrastructures will pose a big challenge.

Prospects of Integrating Artificial Intelligence into the Mathematics Classroom

a. Creativity via Guided Discovery Learning

In the context of mathematics education, exploration and creativity are essential components that often require an element of randomness. Intelligent Tutoring Systems in order to facilitate specific learning outcomes and target performance can incorporate environments that enable students to freely explore problem scenarios where the system alternates between tutor-like guidance and open exploratory environment based on specific learning context. This is a perfect example of guided discovery learning which is very rich for creativity in learning mathematics. A subfield of machine learning known as reinforcement learning has been applied in robotics where an agent interacts with an environment to learn how to maximize positive responses over time following its innate set of rules through exploration and learning. Thus, as advances in artificial intelligence continue to improve, creativity which is considered a human trait that AI does not have can still be exhibited by AI techniques that involve exploration and learning from interactions.Scardapane and Wang (2017), comprehensively reviewed how randomness can be used to initiate exploration through neural networks. AI systems will exhibit creative problem-solving abilities guided by randomness and challenge the traditional notion of AI's limitation in creativity.

This paper aligns with the argument of Viberg et al, (2023) and many scholars that the best scenario for creativity in the mathematics classroom can be harnessed through the combination of advanced digital tools with sound pedagogy.

b. The Goal of Modelling

Considering that AI is expected to exhibit a fair amount of generalization in order to be effective in managing the mathematics classroom. Kansky et al (2017) noted that, generalization is a capability that humans are particularly very good at. This underscores the need for advanced AI systems to develop complete teacher models that can propel the interdisciplinary nature of mathematics and model student that understand multiple mathematical fields and can generalize knowledge effectively. The Generative Pre-Trained Transformer (GPT-3, GPT-4), a neural network built by Open AI that contains 175 billion parameters and was trained on 45 TB of text data is currently attempting to managing this requirement, advanced evolutions are still being worked on in the field of robotics to provide more efficient and effective AI models for the mathematics classroom (Brown et al, 2020).The argument by Golding and Lyakhova (2021) that integration of digital technologies in mathematics education is restructuring traditional student-teacher dynamics and erasing boundaries between in-school and beyond-school learning environments comes to bare here, yes the COVID 19 pandemic have revealed that technology can impact negatively on social, cultural and emotional dynamics of teacher-student interactions on both teaching and learning perspectives, but this surely heralds the intense value of utilizing both digital and traditional methods to complement each other in facilitating meaningful learning of mathematics both inside and outside the classroom.

c. AI Working with the Human Teacher

Chan and Tsi's (2023) study sought to answer the question: will AI replace or assist teachers in higher education. Their findings where very interesting to the discussion title above, their survey results captured positive attitudes of teachers and students towards the integration of generative AI technologies in education with students believing generative AI technologies can provide guidance for coursework as effectively as human teachers, more so than teachers do. However, both groups did not strongly believe that AI technologies will replace teachers in the future as they not only concluded by stating that "the future of education lies in the synergy between human teachers and AI" but also, recommended the provision of educational environments that effectively balance the strengths of teachers and AI. Another reviewed study by Melchor, Lomibao, and Parcutilo (2023),explored the potential of AI integration in mathematics education for generation alpha, they claimed that despite challenges of infrastructure and data privacy concerns, biased and error prone responses;

progress in adopting AI integration to prepare students for the digital age is gradually gaining grounds. They strongly promoted the role of AI in education for shaping innovative and inclusive learning experiences for Generation Alpha learners and recommended that understanding this Generation Alpha's perspective on exemplary teachers will better prepare tertiary institutions for future learners. Guided by ethical principles and human values, educational administrators and governments leaders of both developed and developing nations are increasingly interested in harnessing AI's potentials and embracing the integration of artificial intelligence to ameliorate their educational system.

Also, the potential challenge of technology in the classroom leading student to engage in less formal use of digital technologies can be mitigated with the presence of the human teacher as facilitator of the engagement to ensure student focus more on educational contexts. This forms an environment where the affordances of students are strategically tailored for the promotion of essential mathematics concepts and improved positive engagement through continuous collaboration.

d. Towards the Future

Currently there are many intelligent roles of AI technologies that teachers can use in their classrooms to improve teaching in terms of assessment recording, information storage and retrieval, class management, curriculum dissection and repetitive task handling, making the classroom facilitation relatively easy and timely. New advances have brought conversational AI found to provide individualized feedback and practice opportunities for students, which can be lacking due to teacher workload, allowing teachers to focus on decision-making aspects of the instructional process (Ji, Han &Ko, 2023). Vaerenberg and Perez-Suay (2021) pointed out a catalogue of techniques like information extractors, reasoning engines, explainers, and data modelling and demonstrated that by linking further advances of these mechanisms with existing and new researches in AI and mathematics education, the emergence of standard AI-based applications for mathematics education and their integration and adoption in mathematics classrooms in the future will be sustainable. Their analogy is supported by Hwang and Tu's (2021) bibliometric mapping analysis and systematic review study on the roles and research trends of AI in mathematics education, where their findings lead them into promoting the integration of AI technologies, such as personalised guidance systems and adaptive learning environments, to improve learning outcomes and address future challenges in mathematics education. Furthermore, Lee and Perret's (2022) report also yielded credence to the positive reception of the integration approach by STEM teachers, the domineering role of modular curriculum units tailored to subject areas in enhancing teacher engagement and student learning outcomes

Summary

This paper agrees with Chan and Tsi (2023) that beyond cognitive abilities, AI technologies lack the capacity to master cultural qualities and traditional values in the same way humans do. Through knowledge accumulation, experience, and collaborations, teachers serve as crucial communicators with parents and the community, forming strong pillars for career guidance and mentorship. Human teachers are indispensable in nurturing students' experiential learning opportunities. Despite AI's ability to provide information and support, it lacks the emotional intelligence, cultural sensitivity, and capacity for trust-building essential for students' personal growth and development.

Not all human teachers excel in their ability to adapt their teaching methods and strategies to individual students' needs and engage them in critical thinking, creativity, and collaboration, more so that it is a very tasking job to keep up with when dealing with a large class mixed with individuals of varying experiences. AI systems have been proven to play a vital role in guiding students through classroom interaction, and addressing the unique challenges faced by students with special needs. This consideration coupled with the irreplaceable value of human teachers in education solidifies this paper's disposition on the integration of artificial intelligence into the mathematics classroom hoping that even in the future, AI will continue to advance and support the learning process.

Findings by Melchor, Lomibao, and Parcutilo (2023), proved that despite challenges like infrastructure limitations and data privacy concerns, progress in adopting AI integration to prepare students for the digital age is evident. The younger and upcoming generation have more technical tendencies owing to their usage of technology, some of them do not necessarily own these tools but have in one way or the other (through family and friends, or workshops, conferences and study expeditions) interacted deeply with technological devices and are proficient in the usage. Thus, younger and upcoming generation are already promoting the positive role of AI in education.

Recommendations: Based on the situation as discussed in this write up, the following recommendations are made:

i. Educational institutions should be encouraged to collaborate with global companies like Apple, Google, Microsoft, Meta and government bodies to formulate frameworks and create avenues for training expected of teachers in the invention, procurement and utilization of AI tools for education.
ii. Teachers are to be encouraged to regularly attend and participate in AI conferences and workshops in order to stay abreast with changes and new advances in approaches and tools.
iii. Students should equally be encouraged to seek guidance from teachers and experts while interacting and engaging AI tools in educational contexts.

Conclusion

The future of Mathematics lies in the synergy between human teachers and Artificial Intelligence. Blending the unique qualities of human teachers and AI, students can appreciate the value of human connection supported by intelligent machines in classroom environments that effectively balance the strengths of teachers and learners. The integration of AI into the mathematics classroom will be a welcome idea that will support the knowledge of mathematics in solving real, hypothetical and predicted problems in the universe.

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