

Impact of Artificial Intelligence in Science and Mathematics Teaching in Secondary Schools

Adamu Usman & Ganiyatu Aliyu PhD

Department of Science Education,
Faculty of Education, Federal University Gusau,
Zamfara State – Nigeria

Abstract

The study assessed the Impact of Artificial Intelligence in Science and Mathematics Teaching in Secondary Schools. Its main objective was to assess Artificial Intelligence's impacts in the teaching of Science and Mathematics education and how it improves students' performance at senior secondary school level. Retrospective research approach guided the research in which secondary data were gathered through reviewing varied published journal articles, presentations, repositories and educational databases for analysis. The impacts of Artificial Intelligence in Science and Mathematics teaching at secondary school level were portrayed by the results of the study mainly via Intelligent Tutoring System, Virtual Laboratories and Adaptive Learning. However, issues of teachers' competency, ethics and inadequate facilities were the major obstacles towards efficient incorporation of Artificial Intelligence in Science and Mathematics teaching in our secondary schools. The study finally recommended that: secondary school teachers should effectively be trained on Artificial Intelligence and its educational utilization; there should be strong collaborations between Science and Mathematics educators and all other relevant stakeholders in the field; enough provisions should be made, favourable learning atmosphere and manpower have to be ensured; and that Artificial Intelligence should significantly be integrated into the secondary schools curriculum for the country to compete favourably in the Artificial Intelligence race with other countries in the world.

Keywords: Artificial Intelligence, Science, Mathematics, Teaching, Secondary Schools

Introduction

The term Artificial Intelligence (AI) connotes a system in which machines are designed to mimic humans in different aspects of human endeavors. Phogat and Madan (2018) defined AI as the ability of a digital computer or computer-controlled robot to perform tasks, commonly associated with intelligent beings. These tasks/ functions include the ability to learn, reason, analyze, take decisions, recognize speech and visual perception among others. They also viewed AI to refer to the ability of a computer or a computer enabled robotic system to process information and produce outcomes in a manner similar to the thought process of humans in learning, decision making and solving problems. The ever-increasing widespread of AI technologies (Russel & Norvig, 2016) brings about transformative impacts in almost all aspects

of human endeavors. AI (including robotics, machine learning and natural language processing) has emerged as a foundational force in reshaping industries, economies and societal landscapes worldwide. Technology plays a significant part in helping people connect, survive, and overcome certain constraints (Jin & Hurd, 2018; Ratten, 2020; Lee & Trimi, 2021). AI and machine learning continue to innovate as technology advances (Cockburn *et al.*, 2018; Marr, 2019).

Mijwill, Alsaadi and Aggarwal (2021) asserted that applications of AI in education have received significant and widespread attention, especially during the period of the Coronavirus (COVID-19) pandemic when governments began to encourage the education sector to turn towards e-learning, leave traditional education, leave classes, sit at home, and take lectures. This is the reason that encouraged governments to accept an essential idea about the existing technologies and how to utilise them to help lecturers give information to learners.

A number of different studies mostly in the developed world have concentrated on challenges in the application of AI in education whiles, the opportunities and benefits of AI in education have received infinitesimal attention (Tahiru, 2021). The present study is one of the few that provide an integrated overview of the opportunities, benefits, and challenges that AI adoption presents to the field of education. Today, AI applications have started to spread in education and demonstrate themselves that they are worthy, strong, and able to accomplish the required assignments in the most difficult circumstances as we live in the time of COVID-19 (Khan *et al.*, 2021; Lopez-Cabrera *et al.*, 2021).

Despite all these endeavours, obstacles persist, such as insufficient infrastructure, scarcity of competent educators, and restricted availability of educational resources (Okunade, 2024). These issues have therefore affected the efficacy of scientific instruction in secondary schools nationwide (UNESCO, 2021).

Significance of the Study

Myriad educational stakeholders such as students, teachers, researchers, curriculum planners, governments among others would benefit from the findings of the study if published, in their varied educational practices. Students would benefit when they are engaged in collaborative learning. Teachers would benefit by relieving them off extra duties such as administrative and marking of exams and to make time for research and increase contact hours with students who require that. Researchers and educators would gainfully benefit from the contributions offered by the study to the existing literature or body of knowledge. Curriculum planners would find the findings very useful in their future reviews of curricular to meet the yearnings and aspirations of the country as enshrined in the National Policy on Education. Governments and other policy-makers would benefit from the findings and recommendations of the study in their decision makings on educational practices in the country.

Objectives of the Study

The main objective of the study was to assess AI's impact in the teaching of Science and Mathematics in secondary schools. Specifically, it seeks to analyze the existing state of the art in AI technology in education by investigating the challenges, opportunities, and benefits of adopting AI in education (science and mathematics). The study further seeks to review relevant studies to understand the current research focus and provide an in-depth understanding of AI technology in education (especially science and mathematics education) to guide educators and researchers in designing new educational models.

Literature Review

The use of technology in education dates back to the emergence of 1st generation computers and their subsequent updated versions (Schindler *et al.*, 2017). The use of technology in education is far advanced with the emergence of AI where machines are designed to mimic humans. AI is “the science and engineering of making intelligent machines” or “a machine that behaves in a way that could be considered intelligent if it was a human being” (Mccarthy, 2007). In the 1960s, the US Department of Defense took an interest in AI and began training computers to mimic basic human reasoning. The early work of the Defense Advanced Research Projects Agency (DARPA) marked the beginning of automation and systems that assisted human abilities such as expert systems and smart search systems (Chassignol *et al.*, 2018).

AI has rapidly spread not only in fiction with the use of robots to present AI and human-like characteristics but also providing many specific benefits in every industry. It encompasses anything from Google's search algorithms to self-driving cars, to autonomous weapons (Tegmark, 2015). Today, AI technology is revolutionizing schools and classrooms and making jobs much easier for educators (Lynch, 2018). Over the years there has been a slow but steady revolution in education from using the blackboard to the whiteboard and now the use of projector screens in educational institutions. Although there has not been a significant advancement in the use of AI in education from the 20th century to date, research has shown steady improvement of AI in education through the use of different virtual assisted applications (Carlson *et al.*, 2018). At present, educational materials have become accessible through smart devices (Johnson, 2019). With the application of AI in educational institutions, several administrative tasks have been automated and others are still being automated to give educators more time to spend on students (Wogu *et al.*, 2019). Despite these new technological innovations in education, studies (Bayne, 2015; Botrel, Holz & Kubler, 2015) are of the view that the use of teacherbot and other intelligent applications that mimic human intelligence in education are meant to displace teachers. On the other hand, the Internet Society reported that AI can create new jobs and/or increase demand for certain existing ones (Internet Society,

2017). Buckingham-Shum *et al.* (2016) elaborated on how AI can analyse individual student's performance, preferences, and learning styles through machine learning algorithms. This data-driven approach enables the creation of tailored educational experiences, optimizing the learning process for each student's unique needs and abilities. AI provides many advantages in the service of education (Schiff, 2020 & Gao & Liu, 2021) including the ability to learn personally for teachers and educators and according to their special needs. Automatic correction of learners' answers, and this service saves time and effort by eliminating a large number of papers. Continuous evaluation of learners, which is done immediately or at regular times, according to the teacher's opinion, to assess the extent to which the learner has acquired skills.

Other advantages include: Providing the advantage of distance education (Pregowska *et al.*, 2021) or the so-called virtual education (Greenan, 2021), by providing platforms that help them create electronic classes, the most famous of which is the Google Classroom. Providing modern and advanced methods that help communicate information better through the use of a range of applications offered by companies such as Google applications (Nasution & Nandiyanto, 2021). The ability to create and modify teaching content according to the characteristics of education. Expand opportunities for communication between lecturers and learners through applications that help communicate through teaching content. Increasing opportunities to acquire information and see the latest updates in scientific material through communication between lecturers from different nations worldwide. Create homework for learners in proportion to their study skills to identify and address learners' faults.

There are also the use of Teacherbots (computing solutions for the administrative part of teaching, dealing with content delivery and administrative feedback and supervision) and IBM Watson (question and answer computer system that uses natural language to answer questions posed by a user) which are AI applications that enhance teaching and learning (Goncalves *et al.*, 2016). The development of AI has a profound impact on education and teaching practice. It is changing the teaching methods of teachers and learning methods of students (Xue & Wang, 2023).

Conceptual Framework

AI was first coined by John McCarthy at the Dartmouth Artificial Intelligence Conference in 1956 (Tahiru, 2021). Leading researchers from different disciplines converged to discuss topics on the abstraction of content from sensory inputs, the relationship of randomness to creative thinking, and others that developed the concept around "thinking machines". Most participants envisaged the possibility of computers having capabilities to mimic the intelligence of human beings, but their biggest question was how and when it would happen.

AI is the future that has all the capabilities that can be utilised and executed to achieve a modern educational environment through which scientific material is shared between lecturers and learners. Additionally, AI assists lecturers develop skills and acquire new knowledge in spreading and delivering lessons to learners, communicating with them, and evaluating their performance by conducting a set of examinations and distinguishing between them (Mijwil *et al.*, 2022).

Broadly, AI is categorized into two domains: the weak or domain-specific, which focuses on specific problems and the strong or general with the ability to perform general intelligent actions (Berker, 2018). Berker added that other researchers have proposed that the use of strong AI may lead to chaos and destruction of mankind. Other AI researchers propounded that the emergence of AI in education might displace teachers. In the context of this paper, we refer to AI as the Soft AI since machines currently have not assumed the capabilities to perform general intelligent actions. The use of AI in Science and Mathematics education cannot be overemphasized. Yuki and Sophia the humanoid robots are examples of AI applications in education (Retto, 2017).

Phogat and Madan (2018) outlined the following types of AI.

- i. **Algorithm-** Here the computer executes a function exactly in a way given to it and you want it to do. Algorithms are used for data processing, calculations and automated reasoning.
- ii. **Machine Learning-** Where computers are allowed to learn without completely being programmed. The computer itself learns to analyze, interpret the data and make interferences.
- iii. **Narrow AI-** It is also known as weak AI. This system is designed for one particular task only and follow a set of rules without deviations. Eg. Apple's Siri.
- iv. **General AI-** It is also known as a Strong AI. This system is programmed to perform human cognitive abilities which help it to apply intelligence to find a solution to an unfamiliar task. By this, a computer repeatedly improves itself and can become an ultra-intelligent, superhuman machine that can surpass human intelligence.
- v. **Bot-** This is a software designed to automate the tasks that are usually done by our own, like adding an appointment to the calendar or making a reservation for dinner and so forth.

Hence, AI applications currently influence our daily lives such as in our use of Smart Phones; Google Search; Video Games; YouTube; E-Commerce Sites; Facebook; Robots; ChatGPT; Google Bard; Midjourney and Canva's Magic Features among others though many could not notice it. Consequently, the following are the top ten applications provided by AI that can be utilised in education:

1. **Smart Content Creation:** enables machines to update their data and create digital content to archive and digitise books according to the user's desire (Ahmed & Ganapathy, 2021).
2. **Profiling and Prediction:** Lecturers can schedule study materials and take tests to find out and measure learners' performance and what their weaknesses are (Luan & Tsai, 2021).
3. **Intelligent Robots:** Take advantage of the activities of Intelligent robots to help lecturers manage teaching through robots that can add excellent content in sharing scientific material with learners (Cox, 2021).
4. **Intelligent Tutoring Systems:** through which the study material is given and then strengths and weaknesses are diagnosed, feedback is provided to learners, and the most important matters that must be given in the semester (Guo *et al.*, 2021).
5. **Assessment and Evaluation:** Here, learners are assessed and evaluated by conducting a series of quizzes and examinations and directly marking them to assess the extent of students' understanding and judge the level of absorption of the scientific material in the semester (Azis, Abou-Samra & Aprilianto, 2022).
6. **e-Scheduling and Predictive Analysis:** By applying predictive computing, AI can follow the lecturer's behaviour by tracking the lecturer's habits through the classroom and presenting appropriate study schedules for them in less time. The most significant thing that distinguishes intelligent robots from humans is that it does not get tiring and does not feel bored (Chen *et al.*, 2021).
7. **Adaptive Education Environment:** It is a set of platforms that support scheduled teaching by creating an electronic environment similar to the traditional real-world environment so that both lecturers and learners can interact in an excellent manner without concerns.
8. **Virtual Reality Action Interactive Teaching:** AI helps in making all the contents of traditional reality into virtual reality and create an environment similar to real reality and can interact with it clearly, easily and without restrictions.
9. **Identify Classroom Weakness:** The learner's weaknesses can be identified, alerted and their condition treated through a set of analyses of the test impacts carried out by lecturers to study the effect of the scientific material in the electronic classroom while the lesson is indeed understood.
10. **Tasks Oversight and 24/7 Assistance:** AI applications and techniques can manage duties and execute them in a perfect manner and without any concern.

Methodology

The study aims to explore an in-depth analysis of leveraging Science and Mathematics education through AI. Therefore, as the study centered largely on secondary data, it used the

retrospective research approach (Okunade, 2024) in which past data were analyzed to get insights into the creation and impact of AI in teaching Science and Mathematics in secondary schools. The methodology enables the analysis of AI patterns and fluctuations in education processes over a period of time in a particular place. The design provided the direction and structure for the organisation and implementation of the research process in which pertinent secondary data sources, such as educational databases, government papers, academic journals, and other repositories housing data on Science and Mathematics education and the integration of AI in Nigerian secondary schools. An extensive literature review was undertaken to discover and examine current research, papers, and publications pertaining to the incorporation of AI in Science and Mathematics education.

Discussion of Findings

Stem 1: Impacts of Artificial Intelligence in Science and Mathematics Teaching

As an innovative means of transforming the conventional teaching strategy suitable for Science and Mathematics education, the AI tool called Adaptive Learning System (ALS) emerged in the world today. The main aim of the ALS is to individualise the learning process for every learner, departing from the standardised approach. It thus employs advanced data analytics and machine learning algorithms to thoroughly examine the performance of each student, accurately determining their strengths, limitations, and preferred learning methods. With this abundance of information, ALS is able to customise content delivery by providing personalised learning pathways, tools, and exams that are specifically designed to meet the individual needs of each learner. This is in line with the findings of Adeyemi (2020) that ALS is highly advantageous to students by fixing knowledge deficiencies and increasing students' participation and enthusiasm by providing a customised and pertinent educational experience.

Another AI technology having positive influence on Science and Mathematics education is the Intelligent Tutoring Systems (ITS) which simulate the functions of a human tutor by providing individualised and interactive instruction to students. The major features of the ITS are: the capacity to adjust to the learner's speed and preferences; incorporation of natural language processing to enhance interactive experiences; and use of diagnostic tests to customise courses according to individual learners' needs. ITS greatly enhances the efficacy of scientific and mathematical teaching by providing tailored assistance and all-round accessibility. However, in order to guarantee a comprehensive learning experience, it is pertinent to overcome some obstacles such as technology limitations and find a way to strike a balance between digital interactions and human participations.

Other vital AI technologies of paramount importance in Science and Mathematics teaching are the Virtual Laboratories and Simulations. These simulations offer authentic settings, enabling students to do experiments, alter variables, and examine results without the

necessity of physical laboratories. Virtual laboratories provide students with an engaging and immersive learning experience by including interactive elements and emphasizing their safety. They also control the obstacles associated with scarce resources by offering opportunities to conduct experiments and utilise equipment that may otherwise be inaccessible. However, technological infrastructure and the genuineness of the experience are some of the things that must be taken into cognizance here. This is confirmed by Nguyen and Rasmussen (2016) who found that ALS, ITS, and Virtual Laboratories/Simulations in Science and Mathematics education showcases the revolutionary capacity of AI by tackling the conventional difficulties and facilitating personalised, captivating and efficient learning experiences for secondary school students in Nigeria and other places.

Stem 2: Impediments to Successful AI Utilization in Science and Mathematics Teaching

Challenges persist in impeding the successful utilization of AI in Science and Mathematics teaching. These include: Insufficiency of resources, electricity, internet and adapting to new learning modality (Mina *et al.*, 2023). The identified gap suggests that institutions must strategically allocate resources, including training initiatives and updated technology, to facilitate seamless AI integration (Olatunde-Aiyedun, 2024).

While many writers and government ministries have expressed their hope that AI will save teacher time (Miao & Holmes 2021b), others have suggested that AI will at some point make teachers defacto redundant, or at least their role will be reconfigured as classroom orchestrators/technology facilitators, tasked with managing learner behaviour and ensuring that the technology is switched on (Seldon & Abidoye 2018). AI is not capable of the depth of interpretation or accuracy of analysis that a human teacher can give (Holmes *et al.* 2019).

According to the Internet Society (2017), the focus of most AI applications currently is on machine learning which does not require programming but rather the application uses inferences to learn and adapt to users' trends. In this situation, data becomes the most valuable resource for AI implementation and continuity. This also suggests that privacy, trust, ethics, and other socio-economic issues must be taken into consideration when implementing AI in education. The requisite skillset of staff and infrastructure (Tahiru, 2021) are important factors to consider in the adoption of new technology since they are considered the driving force for successful implementation. Tahiru further opined that people (programmers, teachers and students among others) are the main problem of AI in education and not the technology itself. Everett (2019) argued that a key ethical issue raised by literature is accountability. If issues come up in AI systems how is it going to be addressed? For example, who oversees data and if data leaks who is held responsible? What if the AI system does not assess students fairly in exams?

Stem 3: Chances in AI Utilization in Science and Mathematics Teaching

To successfully harness learner's potentials in Science and Mathematics teaching, some aspects of AI technologies are increasingly being included in secondary education (Science and Mathematics included), usually as part of overall digital literacy and mostly in computing classes, and very occasionally as part of an AI curriculum.

There are several opportunities available for teacher training and professional development, such as workshops, seminars, and online learning platforms that specifically focus on AI education. By incorporating AI-related material into teacher training programmes and mainstream scientific curriculum, promoting the formation of collaborative learning communities among teachers, and offering incentives for ongoing education, we may enhance the competence and expertise of the teaching staff.

Stem 4: Fate of AI in Science and Mathematics Teaching

Sub-Stem 1: Anticipated Developments in AI for Science and Mathematics Teaching

With AI becoming inevitable in everyday life, preparing for the impact of AI is increasingly important for everyone (Markauskaite *et al.*, 2022). Adding that, one way in which these issues might begin to be addressed is by encouraging all teachers of subjects ranging from the sciences to the humanities and arts, and not just the ICT or computer science teachers to explore with their students the potential uses, benefits, impacts, challenges and risks of AI in their subject areas. The different types of transformation AI might proffer to Science and Mathematics education in our schools include but not limited to the following.

Automation of Administrative Task: AI can be applied (Johnson, 2019) in the processing of repetitive administrative tasks that will save educators or lecturers from spending long hours in grading and assessing exams and homework respectively. Adding that with regards to multiple-choice exams, technology exists that can grade students. However, when it comes to essay-type exams, serious challenges arise as to whether the technology could be employed to award grades. Software developers are still researching and coming out with ways of grading written answers and essay type questions. Similarly, AI is being used for processing the admission of new students into educational institutions.

Smart Content: Another AI application in education is the Smart Content. Smart Content is an AI technology, which (according to Faggella, 2019), attempts to condense textbooks into a useful tool for exam preparation such as true or false. Some examples of some well-known Smart Content Apps are Cram101 and JustTheFacts101. Accordingly, smart content can also include virtual content like Video Conferencing and Video Lectures. Cram101 uses AI to make textbook contents more coherent, and it is easy to navigate by introducing chapter summaries, flashcards, and practical tests. There is also a Netex learning AI system

that enables the creation of electronic curriculum and educative information. Netex, according to Johnson (2019), includes online assistance programs, audios, and illustrative videos.

Intelligent Tutoring System (ITS): is a human guide and facilitator for use in a variety of educational environments. This area of research has been the goal of AI researchers since the 1970s and 1980s (Faggella, 2019). Adding that the idea of self-tutoring was developed by an educational psychologist named Benjamin Bloom in the 1970s. ITS has gained much progress in the research field, and for example, Carnegie Learning's "Mike" Software applies cognitive science and AI technologies to create a personalized tutoring system for students (Singh, Ahuja & Kumar, 2018).

Sub-Item 2: Successive Influence of AI on Science and Mathematics Teaching

According to the AI Market in the U.S education sector report, AI is likely to grow by 47.77% from 2018 to 2022 in U.S education. With the growing concern of AI in every aspect of our everyday life, there is no doubt that the most popular Technology companies like Facebook, Google, Apple, and Microsoft continuously invest in the development and research of AI technologies (Goncalves *et al.*, 2016). The use of AI has proved to be a viable method for creating a meaningful learning experience for students (Conklin & Hartman, 2014).

AI technology holds tremendous potentials for enhancing the quality of education at all levels of study. The key advantages of AI can be summarized as follows: (1) enhanced learning outcomes; (2) time and cost efficiency; and (3) global access to quality education. As AI technology continues to advance, it will generate new and unimaginable applications in education. One of the most exciting future opportunities involves the fusion of AI and virtual reality to provide learners with visually rich educational content. Another direction for future application is lifelong learning, where AI is poised to transform the landscape of continuous education and upskilling, laying the foundation for a more adaptable and resilient workforce in the future (Kamalov *et al.*, 2023).

Conclusion

Numerous publications highlighted the application of AI but the ones that specifically present the relation between opportunities, benefits, and challenges in education are still scattered and few. From the findings, AI opportunities provide a clear indication of how AI can impact positively on Science and Mathematics education. In order to fully gain from AI, a balance must be struck between the machines that optimize tasks and the people that use the machines. The aim of AI in the classroom shouldn't be to replace educators. It should make their jobs easier. Adaptive learning systems and intelligent tutoring systems have demonstrated efficacy in delivering customised learning experiences that are specifically adapted to the unique needs of each learner. Also, the use of virtual labs and simulations has augmented practical comprehension and experimentation, surmounting conventional constraints on

resources. Sufficient funds and resources should be assigned to facilitate the use of AI technology in schools, tackling infrastructural obstacles and offering ongoing professional development for instructors. Teachers at the classroom level should be motivated and provided with the necessary resources to effortlessly incorporate AI tools into their teaching approaches

Academic researchers in AI in education were fewer from 2010 to 2015, however, advance research commenced from 2016 to 2019, with most of the literature obtained from 2018. Majority of studies focused on the challenges in adopting AI in education while opportunities and benefits recorded quite appreciable numbers.

Suggestions

1. Secondary school teachers should effectively be trained on AI and its educational utilization so as to equip and make them equal to the tasks of AI integration in their teachings. This can be done through capacity building workshops, seminars, symposia, retraining by the professional bodies like the Science Teachers' Association of Nigeria (STAN) and Mathematical Association of Nigeria (MAN).
2. STAN and MAN should promote strong collaboration between Science and Mathematics educators and all other stakeholders in the field in order to have a holistic approach to the issue at hand. This can be done through capacity building workshops and seminars.
3. The Federal and State Governments should provide enough provisions of AI gadgets should be made in all our schools so as to facilitate smooth and viable AI application for maximum understanding and improved academic performance amongst students.
4. Favourable learning atmosphere and manpower in AI incorporation and utilization have to be ensured by the governments in order to pave way for efficient and effective teaching and learning processes in our schools.
5. AI should significantly be integrated into the secondary schools' curriculum by the curriculum developers for the country to compete favourably in the Artificial Intelligence race with other countries in the world.

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