



Artificial Intelligence: Innovative Approach in Teaching STEM in the 21st Century

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Abstract

Education, is a powerful tool for change that has evolved through various historical, social, and philosophical shifts due to changes in the world, Artificial Intelligence (AI) stands at the forefront of transformative technologies poised to revolutionize education worldwide. In order to ensure innovative approaches in teaching stem education in schools, this paper explores the potential of Artificial Intelligence (AI) in transforming Science Technology Engineering and Mathematics (STEM) education teaching, owing to the importance of science in nation building. It is important to look at a transformative shift in pedagogy and learning outcomes. As society increasingly relies on digital technology, in teaching, thus, this research examined, the concept of STEM Education, concept of artificial intelligence (AI), why artificial intelligence (AI) should be used in stem education, with a view to assessing how AI tools can be used in stem education in this 21st century. The paper also looks at some challenges of using AI, and suggestions were made on how best AI- driven learning tools can be integrated and use in STEM to enhance the teaching and learning within STEM domains. The paper concluded that to ensure proper balance of the integration of AI into the educational system, educators should be properly trained in the use of AI tools, the government should subsidies most of the AI devices and tools for it to be easily assessed and affordable.

Keywords: Artificial Intelligence, Challenges, Innovative Teaching, STEM Education

Introduction

The incorporation of technology into the education system has been a transformative force, significantly causing a paradigm shift into how we teach and learn. This new set of educational technologies, particularly AI, is directly or indirectly reshaping educational landscape and settings. In this digital era, educators continually seek tools that can transform the classroom experience for both teachers and learners. There are insufficient instructional resources to support teachers in their teaching. Teachers and students made every effort to make teaching and learning practicable, accessible, and unhindered (Kataria, 2018; Raja & Nagasubramani, 2018). However, technology is increasingly been used in teaching and learning in schools. One of such technology is artificial Intelligence (AI). It has made considerable progress in becoming an essential component of the education sector. According to UNESCO (2021), fifty percent of

worldwide organizations have incorporated artificial Intelligence into their day-to-day functions. Similarly, educational and training institutes teach their teachers and students the skills of artificial intelligence. The need for more skilled graduates in Science, Technology, Engineering and Mathematics subjects, is essential for economic diversification and technical growth, in our nations. This is because STEM fields are vital in driving technological advancement. The traditional methods of instruction are frequently insufficient to fulfill the ever-changing requirements of the job market, even though STEM education is widely acknowledged as a potential answer. However, the influence that artificial intelligence has on students' employability is still poorly understood, even though it has emerged as a promising instrument to improve STEM education.

Stem Education

STEM education, an acronym for Science, Technology, Engineering, and Mathematics, is an interdisciplinary approach to learning where academic concepts are coupled with real-world lessons. STEM education involves an integrated approach to teaching and learning in these areas, which emphasizes practical application, problem-solving, and the development of key skills necessary for success in the 21st century (Barth & Muehlfeld, 2022). STEM education is a teaching approach that integrates theories and concepts of science, technology, engineering and mathematics to create a learner-centered learning environment in which students work to find solutions to real-world problems. Students who study subject like STEM areas from the secondary school get exposed to analytical, problem-solving, creativity and innovation associated skills that are useful to Address real-world problems in a technology driving economy (Adolphus & Otuturu, 2022). STEM education encourages a multidisciplinary approach to problem-solving and gives students a comprehensive perspective on how to address complex challenges in the modern world. Each stem component brings a valuable contribution to a well-rounded education and pervades every part of our lives. Adeola (2017) posited that STEM education would be the new basic features and needs that support learning in the twenty-first century. This is because students who can acquire or become aware of STEM skills will always progress or fit in any job market..

What is Artificial Intelligence (AI)?

AI refers to computer or machine that are designed to perform tasks that usually require human intelligence. This includes learning, understanding language, recognizing patterns or solving problems, and making decisions based on algorithms and data. (Kamalov et al., 2023; Käser & Alexandron, 2023; Zador et al., 2023). Similarly, AIs are programmes or tools created for

technology devices like the computer system to simulate the human intelligence by analyzing massive amount of data and recognizing patterns, much like how students learn from textbooks, examples and repetitions (Russell & Norvig, 2020). These programmes are intelligent learning systems that are developed to adapt to particular or specific learning abilities to lead to improved learning outcomes and hands-on activities. The introduction of AI to the educational system will be of great importance to the system on how educational contents are delivered, assessed and interacted with by the users (students and teachers). Mohammed and Watson (2019) defined artificial Intelligence as the skillful manner of machines or technologies programmed to imitate humans. Consequently, Popenici and Kerr (2017) posited that artificial Intelligence is advancing faster in the services and educational systems. It is geared toward automated individualized education to support students of all levels of education through virtual engagement at the student's convenience and time. Raja and Nagasubramani (2018) added that it is much more interactive, making knowledge transfer easy and convenient, demonstrating that reliance and dependency on this technology make life easier and smoother, among other things. Artificial Intelligence (AI) has infiltrated every aspect of human activity, including education, and hence, the areas of science, technology, engineering, and mathematics (STEM) are not exempted to its effect.

Why Use Artificial Intelligence Tools in Stem Education Teaching

UNESCO believes that STEM courses are critical in preparing youth for the future. Belland et al. (2020) argued that artificial Intelligence had impacted STEM students by (i) providing instructional tools, suggestions, or ideas that aid in knowledge acquisition, (ii) providing a guide to the students on how to use the available instructional resources; (iii) causing the students to reflect on things as they engage in the learning process; and (iv) assisting and guiding the students to solve real problems. Artificial Intelligence (AI) continues to revolutionize Science, Technology, Engineering, and Mathematics (STEM) education, transforming educational practices and outcomes in unprecedented ways. Integrating AI into STEM learning environments can improve educational experience and provides students with the requisite skills to thrive in a technology-driven world. Studies have found that Artificial intelligence has been impacting STEM education in the areas of Personalized and Adaptive Learning, and through these learning experiences, AI has introduced a paradigm shift in the delivery of education. Unlike traditional one-size-fits-all teaching methods. UNESCO (2022) reported that the increasing advancement of artificial Intelligence in conjunction with STEM has greatly assisted in learning robotics and cloud computing, transforming disciplines, economies, and industries through human/machine collaboration.

Enhanced Learning

AI-powered platforms analyze individual student performance data to tailor instruction to their unique learning styles and needs. This adaptive learning approach ensures that students receive the right level of challenge and support, thereby improving their comprehension and retention of complex concepts easier to understand. AI can also generate personalized content and learning pathways for learning that fit each student, which helps them get more involved and understand STEM better. AI-driven tools such as intelligent tutoring systems, educational chatbots, and gamified learning platforms promote active learning and sustained engagement. By incorporating real-time feedback and interactive elements, these tools cater to students' curiosity and maintain motivation. For instance, platforms like Carnegie Learning and Squirrel AI offer AI-based tutoring that simulates human-like feedback, fostering deeper engagement in mathematical and computational thinking (Holstein et al., 2019). Moreover, AI-supported virtual labs and simulations allow learners to explore scientific concepts in immersive environments, making abstract concepts more real and enjoyable (Zawacki-Richter et al., 2019).

Personalized Learning

Personalized Learning Experiences AI algorithms can analyze student performance, tailors' contents to meet each students' needs in learning at their pace and time, and identify areas in which they need extra support and provide targeted, adaptive learning experiences that are tailored to each student's needs and pace. This makes it easier for students to learn efficiently and effectively. Kumar (2023). Another significant impact of AI on STEM education is its potential to bridge accessibility gaps. AI technologies can provide personalized support to students with diverse learning needs, including those with disabilities (Cheng & Lai, 2020). For instance, AI-powered speech recognition and text-to-speech tools can assist students with hearing or visual impairments, making STEM education more inclusive. Additionally, AI can extend the reach of quality STEM education to remote and underserved areas, where access to resources and skilled educators may be limited. AI's role in STEM education extends beyond knowledge acquisition and fosters innovation and critical thinking among students. Project-based learning integrates AI to encourage students to tackle real-world problems, develop innovative solutions, and engage in critical thinking (Holmes et al., 2019). This approach prepares students for future careers in STEM fields and equips them with the skills to become leaders and innovators in an AI-driven economy. AI can transform STEM education into a global collaborative endeavor (Pedro et al., 2019; Marshall, 2009; Lee & Perret, 2022). Through AI-enabled platforms, students from different cultural and geographical backgrounds can

collaborate on projects, share knowledge, and learn from each other. This global perspective is essential in today's interconnected world, where many challenges, such as climate change and public health, require collaborative, cross-disciplinary solutions. Notwithstanding, the area of Data-Driven Educational Strategies has an immense impact as AI's ability to analyze vast amounts of educational data enables schools and policymakers to make informed decisions that can enhance STEM education outcomes. By identifying patterns in student performance, AI can help educators pinpoint areas where students struggle and develop targeted interventions (Kamalov et al., 2023). This data-driven approach grounds educational strategies in evidence, resulting in more effective teaching and learning practices.

Improved Accessibility: To bridge the digital gap in some places, offline tools are used. Apps that diagnose plant or health issues can be preloaded and worked on without internet, which is perfect for rural communities (UNESCO, 2023).

Artificial Intelligence Tools Used in Stem Education

AI tools create an adaptive, personalized learning environment, encouraging students to apply STEM knowledge across various contexts and tackle complex problems holistically. Artificial Intelligence (AI) is increasingly reshaping science education by enriching how scientific concepts are taught, understood, and applied. AI has become a transformative tool for both students and educators in the science classroom. The goal of AI in education is not to replace teachers, but it's to support for inquiry-based learning experimentation, augment instructional practices, provide timely feedback, automate administrative tasks, and create more personalized and inclusive learning environments. In STEM education, the integration of AI in teaching and research is becoming increasingly important in solving the complex challenges of modern society (Rau, 2022). As a result, students are more engaged and motivated, which is crucial for mastering subjects that are often perceived as difficult. It also found that AI empowers educators by providing them with sophisticated tools that enhance their teaching abilities. The following are some AI innovative opportunities in stem education.

Virtual Laboratories and Stem Simulations

AI-powered virtual laboratories and simulations, are AI-enhanced platforms that create virtual labs such as Labster and PhET, Carnegie Learning in mathematics use AI to assess student interactions and deliver tailored instructional support, by allowing students to explore scientific phenomena in immersive digital environments. These tools replicate the conditions of real-life experiments and provide instant feedback, enabling students to investigate hypotheses, adjust variables, and see the results of their actions in real-life. Its offer student's hands-on

experiences vital for deepening their understanding of STEM subjects. These tools make abstract concepts more tangible and allow students to experiment and learn in a risk-free environment (Zawacki-Richter et al., 2019).

Intelligent Tutoring System (ITS)

These are AI-powered programs that simulate one-on-one tutoring by providing tailored instruction and feedback based on student performance. Tools like Carnegie Learning and Cognitive Tutor are designed to adapt content in real-time, helping students master science, mathematics, and other complex subjects. AI technologies can provide personalized support to students with diverse learning needs, including those with disabilities (Cheng & Lai, 2020). For instance, AI-powered speech recognition and text-to-speech tools can assist students with hearing or visual impairments, making STEM education more inclusive. Additionally, AI can extend the reach of quality STEM education to remote and underserved areas, where access to resources and skilled educators may be limited.

Automate Assessment and Feedback Tools

AI-powered automated grading systems can grade student work automatically, so teachers have more time. These programmes can also look at how well students do and find ways to help them improve. AI can support teachers by auto-grading assignments and exams, saving time while providing uniform and accurate feedback. Automated grading systems use artificial intelligence (AI) to evaluate student assignments and exams, providing immediate feedback and freeing instructors to focus on teaching. These systems can accurately grade assignments, reducing the workload of instructors and providing students with timely feedback (Bretag et al., 2019).. While AI continues to further developments, its role in STEM education is only going to increase to prepare students for the future they will inherit. AI tools such as Grade scope and Turnitin employ machine learning to grade assignments, essays, and problem sets. These systems provide immediate, consistent feedback and can even assess open-ended or subjective responses through natural language processing. These tools, when ethically and effectively integrated, hold the potential to democratize access to quality education, enhance engagement, and support teachers in delivering more efficient and inclusive instruction (Adolphus, 2025).

Challenges of Using AI in Stem Education

The introduction of AI into the educational system faces many challenges despite its potentials, it also introduces significant challenges and ethical considerations. Some of the challenges are discussed below.

Teacher Readiness and Professional Development

Utilizing AI in stem education demands that educators learn the essential skills and knowledge to effectively use AI tools and platforms. However, numerous teachers may lack the expertise or training needed to effectively use AI in their teaching methods. Many teachers are not familiar with AI tools or feel unprepared to use them effectively in their classrooms, which leads to resistance to adoption, especially when technology is perceived as complex, intrusive, or threatening to the teacher's autonomy (Holmes et al., 2021). This makes it difficult to integrate AI into STEM education because it requires proper teacher training, which is frequently lacking. It is essential to introduce professional development programmes and training initiatives to help them learn about AI and new strategies to teach students. By providing teachers with the necessary skills, they can use AI in their teaching effectively and help students learn more in STEM.

Ethical concerns and Data Privacy

Ethics refers to the study of moral principles. In the field of research and technology (Longo et al., 2020), ethics is a measure of the application of these principles to the development and use of technology to ensure that they are beneficial to morals and responsibility. Due to the easy in accessing data/information with the use of AI, there is rising concern for privacy, and security. Using AI in STEM education brings up ethical concerns that need attention. For example, the algorithms, ie, the programme that tells the computer how to learn to operate on its own, or a set of instructions to be followed in calculation or other operations in AI systems might accidentally keep biases going or promote stereotypes, which could lead to unfair outcomes for some students. AI systems require vast amounts of personal and behavioral data to function effectively. This raises questions regarding student privacy, data security, and ethical use of information. Therefore, safeguarding this information is critical for maintaining the confidentiality of the students. Implementation of solid data encryption methods and very severe access controls, along with keeping to regulations such as the General Data Protection Regulation (GDPR), is required for safeguarding student data (Pardo & Siemens, 2014).

Lack of Human Interaction

With the introduction of AI systems in the schools, most students may not be interested in the conventional school teacher-students contact and lost the act of book reading, this makes them lazy. Also, the guidance and mentorship provided by human teachers/tutors is not there.

High Cost and Unequal Access to Technology

Access to digital infrastructure, such as gadgets, fast internet, and smart educational platforms, is a vital requirement for AI-enhanced STEM education. Unfortunately, there is a digital divide because many students do not have access to these necessities, especially those who live in rural or low-income areas. van Dijk (2020) states that this worsens already-existing educational disparities and produces unequal learning opportunities. Schools with limited budgets may also struggle to adopt and maintain AI tools, especially if they require expensive subscriptions or ongoing technical support. Without policy interventions and equitable funding models, AI risks reinforcing rather than reducing educational inequality. Developing and implementing AI tools, including hardware and software infrastructure, can be expensive for schools, especially low resource settings (Zhou, Li, & Kim, 2022).

Suggested Solutions in Using AI in Stem Education

Curriculum Modernization

To prepare students for the future workforce, it is essential to modernize the curriculum by integrating data literacy and AI concepts. This includes introducing new STEM courses focused on the practical applications of AI and embedding AI-related topics into existing STEM curricula. Such revisions will help students understand AI's influence across various industries and equip them with the necessary skills.

Foster Public-Private Partnerships

Collaborations between governments, tech companies, and academic institutions can accelerate the development of localized and context-specific AI tools for STEM education.

Policy Integration/ Ethical concerns and Data Privacy

Clear policy frameworks must be developed to regulate AI use in education. Policymakers should mandate the strategic incorporation of advanced AI technologies into educational frameworks. This initiative will revolutionize teaching and learning by fostering a more dynamic, adaptive, and personalized educational environment aligned with the 21st-century knowledge economy's demands. It's important to design AI systems with ethical considerations, ensuring transparency, accountability and fairness. Teachers and policymakers must discuss the ethical aspects of using AI by making guidelines and frameworks to promote the ethical practices of AI, in STEM education,

Teacher Training and Development

The government should Invest in Infrastructure and Accessibility, and prioritize the recruitment of AI experts to train educators, empowering them to harness AI in their teaching practices. Transforming teachers into tech-savvy facilitators that will maximize AI's potential to create engaging, individualized learning experiences, enhancing STEM education.

Concluding Remarks

The emergence of artificial intelligence created numerous opportunities in Nigerian education, this allows Nigerian educators to integrate AI into STEM disciplines, leading to improved quality and modes of instruction delivery. Integration of Artificial Intelligence (AI) into STEM education is reshaping how teaching and learning occur, offering significant opportunities. To personalize instruction, enhance engagement, improve accessibility, and support data-driven decision-making. It is faced with challenges like high cost of the technology and maintenance, ethical concerns and human interaction need, especially of the students who are still developing.

However, to ensure proper balance of the integration of AI into the educational system, educators should be properly trained in the use of AI tools, the government should subsidize most of the AI devices and tools for it to be easily assessed and affordable. This will go a long way in reshaping the educational system in Nigeria.

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