

LEVERAGING ARTIFICIAL INTELLIGENCE IN SCIENCE TECHNOLOGY ENGINEERING MATHEMATICS (STEM) EDUCATION: PREPARING STUDENTS FOR FUTURE WORK

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ABSTRACT

Science Technology Engineering and Mathematics Education holds a pivotal role in shaping the future of society and humanity at large. As the bedrock of innovation and technological advancement, STEM disciplines are not merely academic subjects but the driving force that fuels economic growth, helping to solve complex problems and enhancing the quality of life. Institutions must respond proactively to the rapid evolution in technology particularly in the use of artificial intelligence (AI). Artificial Intelligence has continued to permeate and reshaping the global workforce and redefining the skill sets required in the workplace. This paper explores the potential of Artificial Intelligence (AI) in transforming Science Technology Engineering and Mathematics (STEM) education teaching, by leveraging of AI into, curriculum content, the role of AI in fostering critical thinking, problem-solving skills, and that will equip students with the competence needed in the modern workforce. The paper also highlights the importance of addressing some critical challenges associated with AI integration such as data privacy, potential biases. technological infrastructure, high cost, digital literacy gap. and suggestions were made on how best AI should be used in STEM teaching.

Keywords: Artificial Intelligence, STEM Education, Innovative Teaching, Problem-Solving Skills, Critical Thinking

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INTRODUCTION

Today's workforce requires a specialized and highly skilled population due to the changes brought by the 21st century. Innovations in technology and economic systems have altered the nature of employment for people. In this digital era, educators continually seek tools that can transform the classroom experience for both teachers and learners. 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. These technologies are used to develop systems that can autonomously analyze data, learn from patterns, make decisions, and adapt to

changing environments. The progress recorded with machine learning (technology) in education has led to the introduction of a more sophisticated innovative digital content generation like generative artificial intelligence (Hu, 2022). Artificial intelligence as an innovative generative language system capable of engaging in sophisticated, human-like conversations (Swargiary, 2024). AI is the simulation of human intelligence. The utilization of AI cut across various industries, including but not limited to healthcare, automotive, gaming, finance, education, and lot more. In the education system, AI has the potential to significantly impact how teachers and students teach and learn by improving efficiency, driving innovation, and transforming institutional operation. Future Directions for STEM Education As technology continues to evolve, STEM education must also adapt to prepare students for the jobs of the future. According to Ravi, 2025. Some key trends shaping the future of STEM learning include, Artificial Intelligence (AI) and Machine Learning in Education. Despite the importance of STEM education to national development, Nigeria lacked sustainable STEM education since its independence and as a result, STEM education has not been able to move the country into industrialization and above poverty level. as observed by Okonkwo (2010), STEM education has failed to produce skilled human resources needed for transformation into national prosperity. This implies that most of Nigeria's development in the direction of modernization has been haphazard leading to acquisition of obsolete technology. Sustainable STEM education development therefore represents a catalytic process for social educational, training and public awareness – the values, behavior and lifestyles required for a sustainable future. This paper explores the potential of Artificial Intelligence (AI) in transforming Science Technology Engineering and Mathematics (STEM) education teaching, by leveraging of AI into, curriculum content, the role of AI in fostering critical thinking, problem-solving skills, and that will equip students with the competence needed in the modern workforce.

Concept of 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 emphasises 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. This is because STEM education equips people with skills such as interactive and productive tasks, assisting in information interpretation, developing skills for team collaboration, and improving logical reasoning.

The Crucial Role of STEM Education

STEM is a concept that promotes a comprehensive approach to understanding and solving complex problems and encourages interdisciplinary learning, problem solving, innovations and creativity (Stewart, 2015). STEM education is becoming important in preparing students for professional careers in a world where technology is increasingly becoming prevalent. However, the effective teaching and learning of these STEM subjects face several challenges that can negatively impact the student learning and performance. AI has emerged as a game-changing force that helps to solve these issues, boost student engagement, and promote deeper learning. AI is significantly revolutionizing STEM education with ease of access to information and knowledge data base, making learning stress-free and easy. Creativity and problem solving is very sought after by employers today and STEM encourages critical thinking learning through doing. Schools with a STEM curriculum allows students to experiment with the material taught in class which helps them dissect underlying problems while creating innovative and adaptive solutions.

How STEM Education Prepares Students for Future Work

Enhancing Problem-Solving and Adaptability

According to Ravi, 2025, STEM learning is not just about mastering technical skills—it also teaches students how to think critically, analyze data, and make informed decisions. In a world where technology is constantly evolving, adaptability is key. STEM education ensures that students can learn new skills quickly, embrace change, and tackle complex global challenges with confidence.

Practical Skills and Problem-Solving Abilities

STEM education goes beyond theoretical learning, equipping students with practical skills and problem-solving abilities that are essential for the modern workforce. By emphasizing hands-on experiences, innovation, and analytical thinking, STEM prepares students to tackle real-world challenges and excel in technology-driven industries.

Hands-On Learning and Real-World Applications

One of the key aspects of STEM education is its focus on experiential learning, which allows students to apply their knowledge to real-world problems. This approach enhances critical thinking, adaptability, and teamwork, making students better prepared for future careers. Effective STEM education connects classroom learning to real-world problems and industry needs. This approach helps students understand the relevance of STEM skills to future careers and motivates them to pursue STEM-related fields. Bybee (2013), argues that students are more likely to engage deeply with STEM subjects when they see how their learning can impact real-world issues, such as environmental sustainability, healthcare advancements, or technological innovation.

Project-Based Learning (PBL)

Students engage in real-world projects, such as designing sustainable cities, programming robots, or conducting scientific experiments. This helps them connect classroom concepts to practical applications. Scientific and Technological Education removes such gaps by producing willing and able graduates who possess requisite technical skills and critical thinking essential for occupation fulfillment. By working together on projects, it fosters collaboration which is another essential component of STEM education. Many STEM careers require individuals to work in teams to solve

complex problems, whether in engineering projects, medical research, or technology development. By working together on projects, students learn how to communicate effectively, share ideas, and leverage each other's strengths to achieve common goals. Collaborative STEM education not only prepares students for the teamwork needed in the workforce but also enhances their social skills and emotional intelligence, which are critical for success in any career (Johnson & Johnson, 1999).

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 analysing massive amount of data and recognising 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 education are not exempted to its effect.

Benefits of the use of Artificial Intelligence (AI) Tools in STEM Education.

1. Saves teachers' time and allows faster feedback to students. AI-driven tools can personalize learning experiences, provide real-time feedback, and help students develop coding and data analysis skills, encourages students to revise.
2. Makes expensive or dangerous experiments accessible and safe. Virtual and Augmented Reality VR-based simulations allow students to engage in immersive STEM experiments, such as exploring space or conducting virtual dissections. Provides interactive, inquiry-based learning. Reduces the cognitive burden on teachers. Interactive learning technologies have transformed STEM education by offering innovative tools that engage students and enhance their understanding of complex concepts. Among these technologies, virtual laboratories and augmented reality (AR) applications stand out for their ability to create immersive and interactive learning experiences. Virtual laboratories provide a risk-free environment where students can conduct experiments and explore scientific concepts without the constraints of a physical lab. This flexibility allows for repeated practice and experimentation, which is particularly beneficial in subjects like chemistry and physics. Virtual labs enable students to manipulate variables, observe outcomes, and develop a deeper understanding of scientific principles. Research has shown that virtual laboratories can significantly enhance student

learning by promoting active engagement and critical thinking (De Jong, Linn, & Zacharia, 2013).

3. Enhances self-paced learning by providing instant explanations. Gamification and Interactive Learning: Using educational games, coding challenges, and STEM competitions boosts engagement and motivation among students. Expanded Online and Remote Learning: Digital platforms and virtual STEM labs make STEM education more accessible to students in remote areas. Promotes student-centred learning.

Issues on the Use of Artificial Intelligence (AI) Tools in STEM Education.

Current AI systems still struggle with grading open-ended, creative STEM problems accurately. Virtual labs may lack the hands-on experience needed for mastering experimental skills in the real world. According to Fomsi (2025), Chatbots can sometimes give incorrect or oversimplified answers, misleading students without critical verification. Students might over-depend on AI autocompletion tools. Over-reliance may reduce critical thinking skills if students follow instructions passively. Not all institutions or students have access to AI tools, potentially widening educational inequalities. The use of AI involves collecting and analysing data. Safeguarding this data is paramount. Educators themselves must be trained not just to use AI, but to understand its limitations and biases. Excessive dependence on AI tools can hinder critical thinking, creativity, and hands-on scientific exploration.

Challenges in Leveraging AI into STEM Education

AI can transform teaching and learning but faces hurdles, such as inadequate infrastructure and resources. As noted by Ibrahim (2024), technical barriers and limited resources hinder AI integration in Nigerian universities. Lin et al. (2023) emphasized that deploying AI requires a significant investment. Wickramanayake and Muhammad Jika (2017) highlighted unreliable internet and unstable electricity as barriers to students' educational use of social media. Therefore, ethical concerns are crucial. Abubakar et al. (2024) raised the issues of data privacy, access inequality, and overreliance on AI, potentially undermining critical thinking. Shahvaroughi Farahani and Ghasemi (2024) warned that algorithmic biases could perpetuate discrimination, especially in marginalized communities. Therefore, a multifaceted approach is required. Abubakar et al. (2024) recommended AI usage guidelines, equitable technology access, and assessments that prioritize critical thinking. Ibrahim (2024) suggests enhanced training for educators to improve AI literacy. Lin et al. (2023) stressed collaborative, multidisciplinary research, and ethical vigilance to ensure that AI serves educational goals while upholding social justice. By addressing these challenges and fostering AI literacy, Nigeria can leverage AI to enhance its teaching and research outcomes (Abubakar et al. 2024, Ibrahim 2024, Lin et al. 2023).

Suggested Solutions to Exploit the Benefits of AI in STEM Education

The followings are some solutions to the listed challenges as outlined by Fawehinmi, et al (2025):

Strengthen Digital Infrastructure and Access: The Nigerian government and private sector should invest in reliable internet connectivity, digital devices, and electricity supply, particularly in rural and underserved areas. AI innovations should be designed to be scalable across different contexts, particularly in low-resource setting to make digital tools and AI technologies more affordable for students and teachers.

Capacity Building for Teachers and Educators: Professional Development and Teacher Empowerment Training programme in AI Competencies to equip teachers with digital literacy

skills and the ability to effectively integrate AI tools into classroom instruction, should be provided to ensure teachers remain proficient in AI-driven pedagogies.

Policy and Regulatory Frameworks: Clear policy frameworks must be developed to regulate AI use in education. for AI adoption in education, addressing issues related to data privacy, algorithmic fairness, and ethical AI use. Establish standards for AI tools to ensure their reliability, safety, and alignment with national educational objectives.

Localized AI Solutions for Nigerian Classrooms: 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, also in designing solutions that address specific learning challenges.

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