TRANSFORMING SCIENCE EDUCATION THROUGH ARTIFICIAL INTELLIGENCE TOOLS IN NIGERIA

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Abstract
Artificial Intelligence (AI) is transforming science education by enhancing teaching, learning and assessment practices. The paper examined how AI tools such as intelligent learning systems can help in skill acquisition by changing how students engage in inquiry, experimentation and problem solving. The article explained the current trends, benefits and challenges of integrating AI in science education in Nigeria. Some of the advantages of incorporating AI technique include: AI driven learning which help in engaging students in problem solving, preparation of virtual laboratories and career readiness in high demands fields such as climate changes. Among the challenges that hinder the widespread use of AI adoption in Nigeria include digital infrastructure, education policies, financial investment, curriculum integration, ethical concern, teacher training. To overcome these challenges the paper recommended increased government funding for AI infrastructure, AI based curricula development, training of teachers and stronger framework for ethical AI use in education. In conclusion, AI has the potential to change science education to a knowledge based economy by harnessing the potential benefits of AI such as tailored learning experiences and improved student's academic achievements. This suggested that AI had a crucial role to play in shaping the future of science education and empowering the next generation of learners.

Keywords: Artificial Intelligence, Science Education, Economic Transformation, Education Technology

Introduction

Science teaching focuses on observation, experimentation, logical thinking, and the knowledge and application of science in practice. In Nigeria, it involves key disciplines including Biology, Chemistry and Physics, and it is a key tool used for socio-economic development of the country (Oginni & Owolabi, 2013, Onwioduokit, 2013). Nigeria has tried to make several reforms in the teaching and learning of science since independence. The reason for these reforms is that the inherited curriculum was too theoretical and lacked of relevance to the developmental needs of the country (Babajide, 2015, Awofala & Sopekan, 2013). Efforts to advance experimentation, discovery and scientific problem-solving (Amadioha, 2016, Ogunleye, 1999, Babajide, 2015) were reflected in the subsequent development of activity-based science curriculum and successive reforms in the national education system.The emphasis on education in science and technology is evident in the National Policy on Education at all levels. The science education in the primary and secondary school levels is to be able to develop scientific thinking, prepare learners for useful living and further education and provide human resource for a modern science and technology-based society (Federal Republic of Nigeria, 2020). Notwithstanding these efforts, science education in Nigeria still has a lot to overcome, such as insufficient equipment in science laboratories, lack of infrastructure, less emphasis on scientific and technological changes, poor teaching methods, and limited budgets for science education (Imoniri, 2025, Nwaokugha & Abiakwu, 2024). These ongoing issues highlight the need for strategies that are able to support the current educational system and enhance opportunities for meaningful science learning.

Such an opportunity has come with Artificial Intelligence (AI). To support personalized learning, scientific inquiry, assessment, and access to learning resources, AI technologies, such as intelligent tutoring systems, virtual laboratories, adaptive learning platforms, and automated assessment tools, are increasingly being explored. AI's role in Nigerian science education is not just about new technological tools, however. The paper suggests that rather than being seen as a threat, AI can be used to enhance and reimagine science teaching and learning, making it more personalized, inquiry-based and human-centered, and cautions against the possible infrastructural, pedagogical, ethical and equity challenges that could prevent its effective use in Nigeria.

Methodological Approach

In this paper, a position paper approach using critical review and synthesis of scholarly literature, policy documents and recent studies on AI and science education will be used with a particular emphasis on the Nigerian context. Thematic analysis of relevant literature was conducted on opportunities, challenges and implications of the use of AI in science education such as teacher preparedness, infrastructure, curriculum, assessment, equity and ethical issues. The literature reviewed was used to glean the current viewpoints on the use of AI in education in Nigeria and to frame an argument for the context-sensitive and human-centered approach to incorporate AI into science education.

Importance of Science Education in Nigeria

Science learning is the teaching and learning of scientific concepts in a systematic way. Wagner (2025) states that science education flourishes when students are engaged in the process of questioning, experimentation, modeling, and reflection. It provides good knowledge and scientific thinking and makes students to have enough scientific knowledge in order to live comfortably in scientific and technological era. In both primary and secondary schools, science education is educative in all the three learners' domains: cognitive, affective and psychomotor. It also supports equality of opportunity by providing curriculum materials, resource persons and laboratory materials. In Nigeria, science is a compulsory subject for all students of the Senior Secondary School level under National Policy on Education, this means that at least one of the three core science subjects is compulsory for all students at the Senior Secondary school level in Nigeria (Federal Republic of Nigeria, 2020). Moreover, science education fosters the local dissemination of

educational resources, so that science learning can also be delivered in a local context that is close to the learner.

Science education in developing nations such as Nigeria is an important means of technological development. But it is hampered by longstanding systemic problems. Oyeniyi (2024) cited several of these, including inadequate funding of government science facilities and science teachers. Poor science teachers' methods of teaching science is another major lacuna, especially when science teachers are not qualified, and which does not enable meaningful engagement of learners. Many schools have limited access to laboratory equipment and hands-on scientific inquiry is difficult to put into practice. Inadequate infrastructure in educational institutions further compromises the learning environment, while a lack of a curriculum that suits the present changing scientific and technological world makes students unfit to meet the challenges of the world (Imoniri, 2025, Nwaokugha & Abiakwu, 2024).

Theoretical Framework

The following are the three theories that support this paper: the Constructivist Learning Theory (Piaget, 1968, Vygotsky, 1978), the Technology Acceptance Model (TAM) (Davis, 1989), and Connectivism Theory (Siemens, 2005).

From the viewpoint of the Constructivist Learning Theory, learners construct knowledge by means of experiences and interaction – by exploring instead of simply taking in information. Piaget (1968) also stressed the active involvement in the environment in learning, and Vygotsky (1978) also emphasized the role of social interaction, language and support from more knowledgeable people in learning. The theory is applicable to science education in the context of AI, as virtual laboratories, simulations and intelligent tutoring systems can create a learning environment for students to explore ideas, test their hypotheses, make mistakes and construct scientific knowledge at their own speed (Kunnath & Botes, 2025, Almasri, 2024).

Davis' (1989) Technology Acceptance Model (TAM) is a model that describes the process of user acceptance and adoption of new technologies. Perceived usefulness and perceived ease of use are the primary factors used in the model. The implementation of AI tools in Nigerian science education is a multifaceted process that involves more than just their availability; it requires teachers and students to see their potential value and usability. When the AI tools are perceived as useful in teaching and learning and not challenging to use, users are more likely to use them meaningfully (Nazaretsky et al., 2022, Treve, 2024).

Connectivism Theory, developed by Siemens (2005), is a theory of learning that suggests learning is happening through connections, in networks of people, sources of information, and digital technologies. To access, connect and use the various sources of knowledge, learners must be able to do so in an increasingly digital learning environment. AI-based platforms, intelligent tutoring systems and other digital tools can be part of these knowledge networks and serve as an access to scientific information, feedback and personalized learning pathways (Siemens, 2005, Garzón et al., 2025).

These theories collectively offer a valuable framework for comprehending the implementation of AI in science education in Nigeria. Constructivism discusses how AI can facilitate active and inquiry-based learning, the Technology Acceptance Model demonstrates the significance of perceived usefulness and ease of use in technology adoption, and Connectivism discusses how digital and AI-enabled networks can enhance access to scientific knowledge. Together, they defend the view of using AI as an aid to, not a replacement for, teachers and students in the science education transformation.

Role of Artificial Intelligence in science education

AI is revolutionizing the way science is learned and taught in basic ways. Now, AI can replicate experiments, produce intricate datasets and analyze learning patterns in real time, so science teachers can dedicate more time to conceptual learning and less to rote

memorization and marking (Treve, 2024, Henze et al., 2024). AI is transforming education globally by providing personalized learning experiences, automated evaluation, and intelligent tutoring systems that boost student engagement and understanding (Chow & To, 2025). It can also potentially achieve the democratization of access to high-quality science education by reducing disparities between students of different backgrounds, interests and abilities, thus becoming a growing concern of both governments and educational institutions (Setiawan et al., 2025).

The capacity to offer personalized learning paths, supporting the specific learning style and capability levels of every student is one of the most important contributions of AI to science education (LeewayHertz, 2022). AI systems monitor student progress continuously with machine learning algorithms, detect gaps in understanding and adapt teaching content to address them, providing personalized support and not a uniformed one-size-fits-all. This is also true for assessment: AI can analyse students' work and provide rapid, consistent feedback and evaluations, allowing science teachers to focus on offering targeted advice and more meaningful in-class instruction (Memarian & Doleck, 2024). Additionally, AI can leverage Natural Language Processing (NLP) to analyze written assignments and essays for content, style and structure, and identify students who are at risk of not achieving their grade level before it is too late (Nazaretsky et al., 2022, Delgado et al., 2020).In addition to personal learning, AI has a lot of practical applications to revolutionize science classrooms. Virtual labs enable students to conduct experiments without risk of injury or damage to equipment, help them test their hypotheses, and enable them to change variables and to understand phenomena like chemical reactions, physics equations, and biological processes (Kunnath & Botes, 2025). The Intelligent Tutoring Systems (ITS) employ natural language processing and machine learning in various subjects, such as chemistry and physics, to offer personalized guidance that adapts to the individual learner's abilities and limitations (Garzón et al., 2025). In addition, AI can help identify students' misconceptions at an early

stage, track their learning progress and significantly alleviate the workload of educators in the assessment process, while maintaining equity in assessment (Delen et al., 2024, Huang et al., 2025). The curriculum level is another where AI-powered data analysis can contribute to the identification of science education gaps by processing extensive data on student performance and learning trends, providing policymakers and educators with a solid foundation for curriculum improvement (Daırıcı, 2025).

Emerging Perspectives and the Need for a Paradigm Shift

The last few years, there have been more studies that have focused on the possibility of using Artificial Intelligence (AI) to enhance various aspects of science education. The literature is mostly focused on the use of AI to create 'personalized learning', intelligent tutoring systems, automated assessment, and data-informed feedback, making teaching and learning more responsive to the needs of individual learners. AI-powered tools can also offer learners access to virtual laboratories, learning resources, simulations that might not be easily available in traditional classroom environments. These applications can enhance student involvement and can help give students opportunities to conduct scientific inquiry and alleviate some of the routine tasks that teachers must do (Almasri, 2024, Eden et al., 2024, Garzón et al., 2025, Setiawan et al., 2025). Now, AI is not just seen as a technological tool, but also as an extension of the teacher's capabilities and a means to make learning more flexible.In Nigeria, though, the context is more complex, with the straightforward use of AI being much more complicated. Research on Nigeria has identified some major issues including poor digital infrastructure, weak internet connectivity, inadequate funding, teacher preparedness, policy gaps and disparity in access to digital technologies (Ekwesianya, 2025, Imoniri, 2025, Nwaokugha & Abiakwu, 2024). These challenges are significant because the advantages of AI are contingent on the context of the educational setting in which it is implemented. However, AI can be less impactful and potentially exacerbate disparities between students and schools when teachers are not confident or skilled in using AI as a

pedagogical tool, or when schools do not have the necessary infrastructure, or when the use of digital tools is unequal. The question is not just about the availability of AI, but also about its context, are all the other conditions available in order to use it meaningfully?

Combined, these attitudes indicate that the real problem is not just the possibility of integrating AI into science education in Nigeria, but the question of how to do so without perpetuating the current structural challenges. This paper therefore proposes to reimagine AI not as a new teaching aide, but as an enablement of a more responsive, inquiry-driven and humanized science education system. To make such a transition, AI needs to make the learning process more efficient and effective, not more stressful or inaccessible, and enhance and not detract from scientific reasoning, nor de-emphasize equity, ethical responsibility or the science process. The focus in the country should, accordingly, shift from the adoption of technology for technology's sake to the purposeful integration of AI into Nigeria's education system, in line with the country's educational needs, resources and wider vision for scientific and economic growth.

Challenges of implementing Artificial Intelligence in Science Education in Nigeria

While AI promises significant benefits for science education, Nigeria's adoption of AI in the field is hindered by a range of infrastructure, policy, financial, human capacity, and pedagogical challenges. The first is the condition of the digital infrastructure. AI-powered education requires consistent internet access, reliable electricity, and well-functioning computers, which are not readily available or accessible in all Nigerian schools. A World Bank is assessment of basic education in Nigeria revealed that while there were approximately 600,000 digital devices in primary and junior secondary schools, 16 percent of these were not working and Nigeria's internet penetration rate stood at around 45 percent as of early 2024, reflecting much deeper gaps at the school level (World

Bank, 2025). These institutions, especially those in rural and underserved areas, often struggle with limited access to basic ICT facilities for the operation of the AI platforms, and the lack of simulated learning environments can further constrain students' opportunities to gain practical scientific skills (Nwaokugha & Abiakwu, 2024, Nnaemeka & Ogunbadejo, 2024).Policy and governance challenges are also closely related to these infrastructural limitations. While Nigeria has been making strides towards the formulation of national policy documents on AI and digital education, there is a significant disconnect between project intentions and execution, especially when it comes to infrastructure, teachers' readiness, incorporation of AI in science education and equity and ethical governance in science education. The gaps have resulted in a lack of central government coordination in implementing AI in schools, with various schools and private organizations implementing their own projects (Imoniri, 2025, Edam-Agbor et al., 2025). In addition, inadequate data protection measures in the use of AI tools to collect and analyze student information pose significant privacy concerns, which have not been fully resolved by the existing legal framework (Udoh, 2024).These obstacles are magnified by a lack of funds. There are significant initial costs associated with implementing AI in science education, encompassing software, hardware, and teacher training. Many schools are simply not able to access AI-driven platforms, exacerbating the disparity between those that have better resources and private schools, and those that lack such resources and public schools (Aminu & Ojerinde, 2024).

Another significant barrier is the teachers' preparation. The findings from these studies consistently reveal that many teachers in Nigeria lack the knowledge of how to use AI pedagogical tools and are often not confident enough to effectively use AI in science classrooms (Ekwesianya, 2025). What is beyond capability is the cultural aspect, which includes resistance to the change in technology and anxiety about losing their jobs, especially in public secondary schools where opportunities for professional development are limited (Imoniri, 2025, Mohammed et al., 2025).

Lastly, AI tools may be available, but they can also be used in a non-critical and excessive manner, creating a pedagogical risk. Recent studies indicate that excessive dependence on AI may hinder students' ability to think critically, reason, and solve problems if it is not properly integrated into human-led teaching and scientific exploration (Zhai et al., 2024, Huang et al., 2025). No risk should be ignored, particularly in science where the skills of handling uncertainty and engaging in empirical investigation are at the heart of science learning.

Benefits of Artificial Intelligence in Science Education in Economic Transformation

The potential of Artificial Intelligence in changing the landscape of Science, Technology, Engineering, and Mathematics (STEM) education in Nigeria is enormous and it can therefore be harnessed for a wider spread of economic development in Nigeria. The challenge of Nigeria's youth population has continued to grow in an environment where the labour market is not providing high-skill jobs (World Economic Forum, 2025) and the country has not been quick enough with the technological adoption. The potential for AI in science education lies in its ability to help prepare students for the future by fostering a new generation of scientists with skills in data science, automation, robotics, programming and machine learning, which are essential for the digital economy. The workforce would also minimize the need for Nigeria to depend on foreign technical assistance while encouraging indigenous technological innovation and help position Nigeria to be competitive in a dynamic global economy (Abubakar & Onasanya, 2025; Federal Ministry of Communications, Innovation and Digital Economy, 2025).

There are already several industries looking for individuals with an understanding of AI. The ability to use data-driven tools and analytical abilities is needed across multiple industries including health, agriculture, finance, manufacturing, and education, and AI-informed science training can help equip up-and-coming generations to capitalize on this demand in ways conventional approaches can't.

But AI isn't just transforming the way people prepare themselves for learning, it is also transforming research and innovation at the institutional level. AI tools are being used in a more advanced manner in universities and research institutions, facilitating deeper data analysis, predictive modeling, and scientific research in various fields (Ahmed & Meraj, 2024). At the global level, AI research has led to significant advances in medicine, engineering and environmental science, such as speeding up the time to market for drugs in the health sector, for example, or understanding patterns in climate change, or designing new materials to store energy (Fudan University & Shanghai Academy of AI for Science, 2025). With the proper investment in AI technology and expertise, Nigeria's universities could benefit from the same momentum.AI is also a catalyst for entrepreneurship. It can offer students and professionals opportunities to create solutions for business and industry using AI, as much as it can offer jobs to them. Meanwhile, AI contributes to more sustainable learning and teaching spaces. It facilitates the personalization of the teaching process, decreases the workload of the lecturer in teaching and assessment, and offers the learner personalized research support and meaningful content (Eden et al., 2024). This is particularly significant because heavy workload has been established to cause stress and burnout among lecturers in Nigerian Universities as evidenced by several studies which has consistently identified it as a major risk to teaching quality and well-being of lecturers (Oderinde et al., 2024).

Implementing Artificial Intelligence in Nigerian Science Education

Implementation strategies for the paradigm shift embody the need to embrace the use of AI as an addition to the science education system, not a replacement for teachers, laboratory facilities or pedagogy. Coordinated efforts are, therefore, needed in teacher training, infrastructure, curriculum development, and policy integration to achieve the successful integration of AI in science education in Nigeria. One of the initial points should be teacher capacity. No matter how well designed the AI platform is, it will be of little value if

teachers are not sufficiently prepared to utilize it. There is need for continuous professional development programs for science teachers in Nigeria, not just the one off approach. Such programs should build teachers' technical, pedagogical and ethical knowledge of AI, aligned with the competencies in the UNESCO AI Competency Framework for Teachers (Imoniri, 2025, Ekwesianya, 2025).Support should be provided to these efforts with the required infrastructure and access. Schools need to invest in robust internet connections, power supply and digital devices, as well as in AI-powered learning resources, to fully benefit from these technologies. Virtual laboratories can also offer extra learning opportunities, especially in school environments where the access to physical laboratory facilities is limited (Nwaokugha & Abiakwu, 2024). Such technologies are not meant to take the place of actual laboratory experiences, however.

The reform of the curriculum must go hand in hand with the training of teachers and the development of infrastructure. AI-integrated STEM curricula should promote inquiry-based learning, authentic assessment and the development of scientific reasoning rather than simply introduce AI as another subject or tool. AI can be integrated systemically into the curriculum, leading to more engaging learning experiences that can help develop the competencies students need to engage in the evolving scientific and technological landscape (Karampelas, 2025).Implementation should be guided by policy, ethics and equity as well. There is a need for clear policies that address data privacy, responsible use, transparency, access and accountability in the use of AI in education. The Nigeria Data Protection Act of 2023 is a crucial foundation for the protection of personal data, with additional guidance required in each sector to ensure responsible use of AI in education. Implementation needs to consider variations in access between schools and learners to ensure that AI does not exacerbate existing educational inequalities. The development of initiatives such as the Nigeria AI Scaling Hub also provides an opportunity for government, educational institutions and technology partners to work together in developing locally relevant and sustainable AI solutions.

Conclusion

The literature reveals that the use of Artificial Intelligence has a potential that is relevant to improving science education, in terms of personalized learning, intelligent tutoring, assessment, scientific enquiry and wider access to learning resources (Imoniri, 2025, Kunnath & Botes, 2025). These applications can be helpful for teachers and learners in providing flexible and responsive learning, and for giving learners opportunities to actively participate in learning scientific concepts and practical problems. The use of AI, however, will not solve the problems of science education in Nigeria. It's effective use hinges on solving problems like inadequate infrastructure, teachers' preparedness, funding, policy, ethics and unequal access (Imoniri, 2025, Samuel et al., 2025). It is important to remember that AI is a tool to assist teachers and students, not to replace them or any other part of the learning environment. To meet the realities and needs of Nigerian schools, an approach that is human-centered and context sensitive is required, in that the use of AI should respond to these. Therefore, Nigeria must shift from using AI to transforming science education with AI. This calls for investments that are coordinated in terms of teachers, infrastructures, curriculum, ethical governance and access to AI to boost scientific inquiry, critical thinking, digital literacy and hands-on learning. The debate about the adoption of Artificial Intelligence in science education in Nigeria is no longer on whether it should be used, but how it can be deliberately integrated to build the capacity of teachers, enrich scientific inquiry and broaden science-related learning opportunities without perpetuating the structural constraints of the current education system.

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