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The Role of Artificial Intelligence in Revolutionizing Basic Science Teaching at Primary Education in Nigeria. A Critical Review

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ABSTRACT

Artificial Intelligence (AI) is reforming the teaching-learning model at a global level and there is a paradigm shift taking place. Though Nigeria has improved, when it comes to teaching science, students still face such difficulties as overcrowded classes, lack of appropriate teaching materials, inadequate lab facilities, and shortages of professionally trained teachers. This article reflects on how AI can revolutionize science teaching at the primary school level throughout Nigeria. It describes the historical evolution of science education in the country; AI applications in personalizing learning; enhanced evaluations and administrative man engagement; and it addresses the opportunities and challenges of AI in Nigerian classes. Utilizing bibliometric analysis as well as recent studies, whether AI-enabled tools, among others, scalable AI (smart tuition systems, virtual laboratory, chat bot), are transforming (i) pedagogy, (ii) students' improvement, (iii) engagement, and (iv) teacher's cooperation towards AI. This paper concludes with policy, infrastructure, and capacity building recommendations that can help to harness the potentials of AI in the science of science education in Nigeria.

Introduction

Elementary level often refered to as basic scientific education forms the foundation of national development by determining to a large extent the intellectual, technological and economic advancement of any nation. In an increasingly dynamic world, with science-driven knowledge and innovation critical to the economic dominion of nations, promoting curiosity and basic scientific knowledge at an early age is very important. Since the formal introduction of science in the primary school in Nigeria, a lot has been achieved and an equal number of challenges resulting from the teaching and learning of the subject. Aina (2010) confirmed that the presence of non-qualified science teachers in primary schools was one of the challenges. In order for basic science to be a good teacher, primary school teachers must pay urgent and appropriate attention, (Momoh (2001). Science is different from all other disciplines and its teaching and curriculum must be different. Akinola (2006) observed that teachers' inadequate methods of teaching and the structure of the curriculum are problems of primary school science education. Uchenna (2005) confirmed that the biggest challenge in education in Africa is the development of educational programmes, especially scientific programmes at all levels of education. Maduabum (1991) stated that primary education is the basis of our educational continuum and requires a solid foundation in science. Science must be implemented by the pupil in primary schools through a good method of education, the use of good educational materials and improvisation if necessary. According to Daniel (2001), teachers need to be exposed to the production and use of available resources in the age of information technology, especially at this time. Countries that prioritize robust science teaching from the earliest years such as China have demonstrated remarkable progress in technological advancement, industrialization, and human capital development. In these contexts, basic science is not merely an academic subject but a strategic tool for nurturing critical thinking, creativity, and problem-solving skills that drive societal transformation.

In Nigeria, the imperative to strengthen basic science education at the primary level is more urgent than ever. Historically, science teaching in Nigeria began under colonial influence, with missionary schools introducing Western science curricula in the late 19th and early 20th centuries1. Despite significant milestones, including the establishment of pioneering institutions and curriculum reforms, primary education continues to grapple with systemic challenges: overcrowded classrooms, insufficient teaching materials, limited laboratory resources, and a shortage of well-trained science teachers. These constraints have often relegated science instruction to rote memorization, undermining students' conceptual understanding and stifling their natural curiosity.

The importance of addressing these fundamental gaps cannot be exaggerated. Basic science education at primary level prepares the foundations for subsequent learning in secondary and higher education institutions, equipping students with the skills they need to interact with their environment, participate in the knowledge economy and contribute significantly to national development. Early exposure to scientific concepts fosters lifelong interest

in STEM fields, strengthens cognitive development and prepares children for an increasingly complex and technologically driven world. As in China, science is introduced as a core topic from the early years and supported by a culture of experimentation and research, early investments in scientific education have led to dividends in innovation, workforce readiness and global competitiveness.

Amidst these challenges and opportunities, the advent of Artificial Intelligence (AI) is heralding a paradigm shift in educational methodologies worldwide. AI-powered tools ranging from intelligent tutoring systems and virtual laboratories to adaptive learning platforms and chatbots are redefining how science is taught and learned. In nations with robust digital infrastructure, these technologies have already demonstrated their capacity to personalize instruction, enhance engagement, and democratize access to quality education. For Nigeria, embracing AI in basic science teaching represents a transformative opportunity to overcome longstanding barriers, improve learning outcomes, and cultivate a new generation of scientifically literate citizens. This review critically examines the role of artificial intelligence in revolution in basic science education in Nigeria, which focuses a special focus at the primary level. It detects the historical context of science teaching, discovers the integration of AI technologies in individual learning and enhancing engagement, and evaluates the challenges and possibilities of AI adoption in Nigerian classes. By drawing lessons from global examples such as China, paper underlines the strategic importance of early science education and provides recommendations for policy, infrastructure and capacity building to maximize AI's ability in Nigeria's educational scenario.

Historical Context of Science Education in Nigeria

Science education in Nigeria developed after independence after a more structured system from the underdeveloped beginning during colonial time. Early science instructions were limited, some students selected for science subjects due to social and economic factors. The establishment of technical colleges and universities in the middle of the 20th century marked a turn, emphasizing laboratory work and practical skills required for scientific literacy (Asolusam, 2016). Basic science education at the primary level is the foundation stone for scientific literacy, important thinking and innovation in any nation. Initial contact with scientific concepts increases a lifetime interest in curiosity, problem-solution skills and stem areas. For developing countries such as Nigeria, embedding a strong science foundation in primary education is necessary to build a knowledge-based economy and address social challenges such as health, technology and environmental stability.

Despite these advances, traditional teaching methods largely reliant on chalkboards and rote memorization have persisted, limiting student engagement and conceptual understanding. The need for innovative pedagogical tools to enhance science learning outcomes has become increasingly urgent, setting the stage for AI integration.

The Strategic Role of Basic Science in National Development

Human Capital Development: Nations that prioritize science education from the earliest years produce a workforce skilled in technology, engineering, and scientific research, crucial for economic growth and competitiveness.

Societal Progress: Basic science literacy empowers citizens to make informed decisions on health, environment, and technology, leading to improved quality of life.

Innovation and Industrialization: Early science education seeds innovation, entrepreneurship, and adaptability key drivers of industrialization and national advancement.

Economic Contributions of Basic Science Education

Basic education enhances personal productivity and national economic performance. Hanushek and Vosman (2008) claim that slight improvements in founder skills can also create significant benefits in economic production. Educated populations are more optimal, technically literate, and capable of contributing to diverse economies. For developing countries, universal basic education can increase GDP growth rate annually by 2% (UNESCO, 2020). In addition, basic education equips learners with numerical and literacy skills, which is necessary for workforce integration, reducing the dependence ratio and increases tax revenue (Baro and Lee, 2013). In agriculture and informal areas, educated individuals adopt innovations rapidly and are engaged in value -added production.

Social Development and Equity

Basic science education is a powerful tool for achieving social equity. It provides marginalized population especially to the disabled with opportunities for girls, rural residents, and weathering (United Nations, 2019). In basic education, gender equality is associated with low child mortality, improvement in family health, and fertility rate (Summers, 1994). In addition, education promotes national harmony by promoting shared norms and values. It helps to reduce crime, ethnic stress and religious extremism by establishing conflict-resolution and important thinking skills (OECD, 2016).

Political and institutional development

A well -educated citizenship is fundamental for the livelihood of democratic institutions and governance. Basic education promotes civil awareness and participation, which are the conditions required for accountability and good governance (Glasar et al., 2004). Empirical study shows a positive relationship between the level of education and the resistance of votes, transparency and powerism (Lipset, 1959).

Comparative Analysis Table: Nigeria vs. China in Primary Science Education

Aspect	Nigeria (Current)	China (Reference Model)
Science in Early Curriculum	Limited, often not prioritized	Core subject from Grade 1
Teaching Methods	Rote memorization, limited labs	Inquiry-based, hands-on, tech-rich
Teacher Training	Inadequate, few science specialists	Continuous, incentivized
AI/Tech Integration	Nascent, pilot projects	Widespread, government-supported
Resource Allocation	Low, especially in rural areas	High, equitable distribution

The Emergence of Artificial Intelligence in Science Education

The role of artificial intelligence technology (AI) is increasingly evident in various sectors, including education. The existence of artificial intelligence technology has transformed educational curriculum, particularly in the fields of technology, science, mathematics and engineering. However, AI will also change the face of the entire education world. The latest technology is artificial intelligence (AI). This technology plays an important role in facilitating various work functions, including in the field of education. AI can also be applied to education. Teachers/teachers can better understand the needs of students (Fitria, 2021). Students can also learn according to their needs without difficulty. It is believed that artificial intelligence (AI) can help people learn better and achieve education objectives more effectively. Therefore, it is not surprising that many AI-based innovations and breakthroughs are currently being applied and will be used to support the learning process in order to make it more practical and effective. Therefore, if artificial intelligence exists in the educational sector and teachers are concerned, it is a challenge to overcome in order to continue the existence of education. Some of the strong beliefs that teachers cannot be replaced by AI are the collaboration of teachers with AI in learning implementation. AI in education refers to the use of intelligent algorithms and systems to facilitate personalized learning, automate administrative tasks, and provide real-time feedback. In science education, AI technologies such as intelligent tutoring systems, adaptive learning platforms, virtual laboratories, and chatbots offer novel opportunities to tailor instruction to individual learner profiles, simulate experiments, and foster interactive learning environments (Ahmad et al., 2020; Al Darayseh, 2023).

Globally, AI is transforming science education by enabling:

Personalized Learning: AI systems analyze student performance data to customize lesson plans, addressing individual strengths and weaknesses (Goel et al., 2024).

Enhanced Engagement: Virtual reality (VR) and augmented reality (AR) simulations make abstract scientific concepts tangible and accessible (Haleem et al., 2022).

Efficient Assessment: Automated grading and AI-driven analytics provide instant feedback, facilitating timely interventions (Basu et al., 2016).

Teacher Support: AI automates routine tasks, allowing educators to focus on pedagogy and student interaction (Nile University, 2024).

AI Applications in Nigerian Basic Science Teaching

Personalized Learning and Adaptive Systems

In Nigeria, AI-Assisted Learning Tools such as chat and Gemini are being used rapidly to personalize scientific education. These platforms are compatible with the learning speed of students and provide targeted exercises and clarifications that improve understanding and retention (Neel University 2024). Adaptive teaching system analyzes individual learning styles and provides personal materials, especially in various classes in Nigeria, where students are ready and capable of speaking at various levels (Ahmed et al., 2020).

Virtual Laboratories and Simulations

Resources of Nigerian schools often limit practical scientific experiments. Artificial intelligence enables students such as labster students to conduct distance simulation experiments, remove infrastructure barriers, and promote experienced learning (Al Darsh 2023). These immersive techniques provide a safe, repetition and cost -effective option for physical laboratories and improve ideological understanding.

Intelligent Tutoring Systems and Chatbots

Intelligent tutoring systems provide individual guidance and immediate response, simulating one-on-one tutoring that is otherwise rare in crowded Nigerian classes (Chen et al., 2020). AI chatbots attach students to interactive dialogues, answer questions, and provide clarification, promote active teaching and curiosity in science subjects (NG, Tan and Lewing, 2024).

Administrative Efficiency and Predictive Analytics

AI automatically automatches the monitoring of grading, attendance tracking, and performance, reduces the administrative burden of teachers and enabling data-mechanized decision making (Nile University, 2024). Predictive analytics recognize students at risk of poor performance, allowing initial intervention to improve results (Nile University, 2024).

Benefits of AI Integration in Nigerian Science Education

Enhanced Student Engagement: AI-driven gamification and interactive content increase motivation and interest in science (Almusaed et al., 2023).

Inclusivity: Assistive AI technologies support learners with disabilities and language barriers, promoting equitable access to science education (Mitra, Lakshmi, & Govindaraj, 2023).

Improved Learning Outcomes: Personalized instruction and immediate feedback accelerate mastery of complex scientific concepts (Kim & Kim, 2022).

Teacher Empowerment: AI tools provide educators with insights into student learning patterns, enabling tailored pedagogical strategies (Al Darayseh, 2023).

Democratization of Education:

Online AI platforms overcome geographical and socio-economic obstacles and expand access to quality scientific education in Nigeria (Seo et al., 2021).

Challenges and Limitations

Despite its promise, AI adoption in Nigerian science education faces significant challenges:

Infrastructure Deficits: Limited internet connectivity, electricity shortages, and lack of digital devices impede widespread AI integration, especially in rural areas (Nile University, 2024).

Teacher Training: Many educators lack the skills to effectively utilize AI tools, necessitating comprehensive professional development programs (Al Darayseh, 2023).

Cost and Sustainability: High costs of AI platforms and maintenance raise concerns about long-term sustainability in underfunded schools (Ahmad et al., 2020).

Cultural and Language Barriers: AI systems often require localization to Nigerian languages and cultural contexts to be fully effective (Nile University, 2024).

Data Privacy and Ethics: The use of student data in AI systems raises privacy concerns that must be addressed through regulatory frameworks (Chen et al., 2020).

Future Directions and Recommendations

To fully harness AI's potential in Nigerian basic science education, the following actions are recommended:

Policy Support: The Nigerian government should develop clear policies promoting AI integration, including funding, infrastructure development, and ethical guidelines.

Capacity Building: Investment in teacher training programs focused on AI literacy and pedagogical integration is essential.

Infrastructure Enhancement: Expansion of reliable internet access and provision of digital devices, particularly in underserved regions, is critical.

Localized Content Development: AI platforms should incorporate Nigerian languages and culturally relevant examples to enhance learner engagement.

Research and Collaboration: Partnerships between educational institutions, technology providers, and policymakers can foster innovation and context-specific AI solutions.

Conclusion

Basic science education at the primary school level provides the basis for latter learning in secondary and higher education institutions, equipped with the skills necessary to involve themselves in the environment, participate in knowledge economies and make significant contribution to national development. Artificial Intelligence has revolutionized the teaching of basic sciences in Nigeria from traditional chalkboard methods to dynamic, individual and interactive learning experiences based on chatbots and intelligent systems. AI's capacity for tailor education, enhancing engagement and supporting teachers addresses many challenges inherent in the Nigerian scientific education scenario. However, to realize the full benefits of AI, it is

necessary to remove infrastructure, training and moral obstacles through concrete efforts by stakeholders. Strategic investment and policy support makes Artificial Intelligence a major advance in Nigerian Science Education and equip the learners with the necessary skills for the 21st century knowledge economy.

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