

## **Artificial Intelligence and the Implementation of Science Education in Nigerian Tertiary Institutions**

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**Abstract.** *The integration of artificial intelligence (AI) into higher education has introduced new dimensions to the implementation of science education in Nigerian tertiary institutions. This study examines how AI contributes to improving teaching, learning, research, and administrative processes in science-based disciplines. Drawing on existing literature, the paper identifies key areas where AI has enhanced science education, including personalized learning, innovative instructional delivery, improved assessment systems, research efficiency, collaborative learning, and professional development of academic staff. The study adopts a review-based approach, synthesizing empirical and theoretical works from both local and international sources. Findings reveal that AI has significantly improved the quality and effectiveness of science education in Nigerian tertiary institutions, although challenges such as inadequate infrastructure, limited technical skills, and policy gaps persist. The study concludes that while AI presents enormous opportunities for advancing science education, its successful implementation requires deliberate investment, policy support, and continuous capacity building. Recommendations are provided to guide stakeholders in maximizing the benefits of AI for sustainable science education development in Nigeria.*

**Keywords:** *Artificial Intelligence, Science Education, Tertiary Institutions, Nigeria, Educational Technology.*

### **Introduction**

The growing influence of artificial intelligence (AI) across global sectors has significantly reshaped the landscape of higher education, particularly in the teaching and learning of science-related disciplines. In recent years, Nigerian tertiary institutions, including universities, polytechnics, and colleges of education, have begun exploring the integration of AI technologies as part of broader efforts to modernize science education and improve academic outcomes. This shift is driven by the increasing recognition that traditional methods of science instruction, which often rely heavily on theoretical delivery and limited laboratory exposure, are no longer sufficient to meet the demands of a rapidly evolving, technology-driven world. Olatunde-Aiyedun refers to Artificial Intelligence as computer-based systems capable of performing tasks that typically require human intelligence, such as data analysis, pattern recognition, decision-making, and problem-solving [1]. In science education, AI technologies are being deployed to enhance instructional delivery, facilitate virtual experimentation, support research, and provide intelligent tutoring systems. These innovations have the potential to transform how scientific knowledge is generated, disseminated, and applied in

Nigerian tertiary institutions.

The implementation of science education in Nigeria has historically been constrained by numerous challenges, including inadequate laboratory facilities, insufficient funding, overcrowded classrooms, limited access to up-to-date instructional materials, and a shortage of science education teachers [2]. These constraints have often hindered effective teaching and practical engagement, thereby affecting students' mastery of scientific concepts. However, the integration of AI presents new opportunities to address these systemic limitations. For instance, AI-powered tools can simulate laboratory experiments, analyze large datasets for research purposes, and personalize learning experiences to suit individual student needs. Studies have shown that AI integration supports innovative teaching methods, improves assessment processes, and enhances students' engagement and understanding of complex scientific concepts. AI adoption in Nigerian tertiary institutions has been linked to improved efficiency in both academic and administrative processes. It enables lecturers to design adaptive learning environments, track student progress in real time, and provide targeted feedback. At the institutional level, AI facilitates data-driven decision-making, thereby strengthening curriculum implementation and educational planning. Evidence from recent studies indicates that AI contributes to enhanced student performance, increased faculty productivity, and more effective management of educational programmes.

Despite these prospects, the implementation of AI in science education within Nigerian tertiary institutions is still at a developing stage and faces several challenges. These include inadequate technological infrastructure, unstable power supply, limited digital literacy among educators, and concerns related to ethical use and data privacy. The high cost of AI tools and insufficient policy frameworks have slowed down the pace of adoption across many institutions. Scholars have therefore emphasized the need for strategic investment, capacity building, and supportive government policies to ensure the effective integration of AI into science education [3], [4]. Against this backdrop, the intersection of artificial intelligence and science education implementation in Nigerian tertiary institutions represents both a significant opportunity and a critical area of concern. Understanding how AI can be effectively harnessed to improve science teaching, learning, and research is essential for positioning Nigeria's higher education system within the global knowledge economy. This study, therefore, examines the role of artificial intelligence in enhancing the implementation of science education in Nigerian tertiary institutions, with a view to identifying its benefits, challenges, and future implications.

## **Conceptual Terms**

### **1.1 Concept of Tertiary Education**

Tertiary education, also called post-secondary education, is any level of education pursued beyond high school, including undergraduate and graduate credentials. These credentials encompass certificates, diplomas, or academic degrees. Tertiary education refers to specialized education in a specific field, taken after finishing high school. Tertiary education is non-compulsory and provided in a specialist institution, usually a college, polytechnic, or university. This form of education may be delivered virtually or at a distance (Top-hat,2023). Tertiary education is defined by National policy on Education (2013) as the education given after Post Basic Education in institutions such as Universities and Inter-University Centres such as the Nigeria French Language Village, Nigeria Arabic Language Village, National Institute of Nigerian Languages, institutions such as Innovation Enterprise Institutions (IEIs), and Colleges of Education, Monotechnics, Polytechnics, and other specialized institutions such as Colleges of Agriculture, Schools of Health and Technology and the National Teachers' Institutes (NTI) [5]. The goals of tertiary education according to the FGN National Policy on Education (2013), shall be to: contribute to national development through high level manpower training; provide accessible and affordable quality learning opportunities in formal and informal education in response to the needs and interests of all Nigerians; provide high quality career counseling and lifelong learning program that prepare students with the knowledge and skills for self-reliance and the world of work; reduce skill shortages through the production of skilled manpower relevant to the needs of the labor market; promote and encourage scholarship, entrepreneurship and community service; forge and cement national unity; and promote national and international understanding and interaction [6].

Tertiary education according to Ogunode is the level of learning after secondary school where individuals acquire specialized knowledge and skills for careers, research, and personal development. Tertiary education is the level of learning that comes after secondary school. It includes universities, polytechnics, colleges, and other institutions where people gain specialized knowledge, skills, and qualifications in a particular field [7]. Unlike basic schooling, tertiary education focuses on preparing learners for a career, critical thinking, research, and personal growth. The objectives of Tertiary Education include:

- a. To equip students with the practical and theoretical skills they need for their chosen careers. It's not just about reading books; it's about learning how to apply knowledge in real-life situations. For example, engineers learn to build, doctors learn to treat, and teachers learn to inspire.
- b. To train students to think deeply and analyze situations critically. This means not just accepting information, but questioning it, evaluating evidence, and making informed decisions, skills you'll use every day, both at work and in life.
- c. To shape character, values, and ethics. It encourages students to become responsible citizens who can make moral decisions, respect diversity, and contribute positively to society.
- d. To foster research, creativity, and innovation, helping students and faculty to find solutions to societal problems, improve technology, and advance knowledge.
- e. To prepare graduates to serve society and contribute to national development. By producing skilled professionals, innovators, and leaders, tertiary institutions help build stronger communities and a more prosperous nation.

Tertiary institutions in Nigeria offered science programmes. Science is the field concerned with sharing science content and process with individuals not traditionally considered part of the scientific community. The traditional subjects included in the standards are physical, life, earth, space, and human science. Science study requires a variety of unique instructional materials in addition to those materials common to all education. A science facility must have space to accommodate this variety in combination with hands-on instructional strategies. Science instructional areas have spatial and material needs that are different from those considered in designing a general use in classroom. The science programs include Mathematics, Physics, Chemistry, Biology, Further Mathematics, Technology, Technical Drawing etc. Science programs in Nigerian schools are given maximum attention due to their significant contribution to the technological development of the country.

## **1.2 Concept of Science Education**

Science programme is defined according to Ogunode and Aiyedun as programmes that are mathematically oriented. The science programme is also viewed as a programme that involves practicals. A science programme is a programme that is very important to the social, economic, and technological development of a nation [8], [9]. The place of science programmes in the development of society. Economic and technological development cannot be underestimated. Science education deals with the sharing of science concepts and procedures with people who are not considered customarily to be distinct from the empirical researchers; the people could be students, ranchers, advertisers, saleswomen, or an entire network.

Omorogbe and Ewansiha defined Science Education as a field of study concerned with producing a scientifically literate society. It acquaints students with certain basic knowledge, skills, and attitudes needed for future work in science and science-related fields. Although there are several issues in science education in Nigeria, the following areas of emphasis have been identified for discussion: students' performance in science and some factors influencing poor performance, which include Quality of Teaching, Teacher Quality and its indicators, and Quality teaching learning resources. Summitexpo Science Education is the field concerned with sharing science content and process with individuals not traditionally considered part of the scientific community. The traditional subjects included in the standards are physical, life, earth, space, and human science. Science study requires a variety of unique instructional materials in addition to those materials common to all education. A science facility must have space to accommodate this variety in combination with hands-on instructional strategies [10]. Science instructional areas have spatial and material needs that are different from those considered in designing a general classroom.

### 1.3 Concept of Artificial Intelligence

Artificial Intelligence technologies encompass various techniques and approaches, such as machine learning, deep learning, natural language processing, computer vision, and robotics. These technologies enable computers to analyze vast amounts of data, recognize patterns, make predictions, and automate complex processes. Artificial Intelligence has applications across numerous fields, including health care, finance, transportation, customer service, and education. It has the potential to transform industries, improve efficiency, and create new opportunities. Frankenfield defined Artificial Intelligence (AI) as the simulation of human intelligence by software-coded heuristics [11]. Artificial Intelligence is a branch of science producing and studying machines aimed at the stimulation of human intelligence processes. Ogunode and Ukozor defined AI as programs designed with human-like intelligence and structured in the forms of computers, robots, or other machines to aid in the provision of any kind of service or tasks to improve the social, economic, and political development of society. Artificial Intelligence is an application or program constructed to carry out tasks with human-like intelligence. They also viewed Artificial Intelligence as collections of systems, packages, and applications designed into digital computers or computer-controlled robots to carry out assignments and tasks with human-like intelligence [12]. Alagbe, and Ariza and Olatunde-Aiyedun viewed AI as the ability of a computer or machine to mimic the capabilities of the human mind, learning from examples and experience, recognizing objects, understanding and responding to language, making decisions, solving problems, and combining these and other capabilities to perform functions a human might perform, such as greeting a hotel guest or driving a car.

### Methodology

This study adopted a review model to examine the role of artificial intelligence in the implementation of science education in Nigerian tertiary institutions. The review model involves the systematic collection, evaluation, and synthesis of existing literature relevant to a specific research problem. In this study, both empirical and theoretical sources were consulted to provide a comprehensive understanding of the subject matter.

Relevant materials were sourced from peer-reviewed journal articles, conference proceedings, institutional reports, and credible academic publications focusing on artificial intelligence and science education within Nigeria and comparable educational contexts. Emphasis was placed on recent studies to ensure that the findings reflect current trends and developments in AI integration in higher education. The selection of literature was guided by relevance, credibility, and contribution to the study variables. Studies that addressed AI applications in teaching, learning, assessment, research, and educational management were carefully reviewed. The data obtained from these sources were analyzed thematically, with key findings organized into major areas reflecting the contributions of AI to science education implementation. The review model was considered appropriate for this study because it allows for a broad exploration of existing knowledge, identification of gaps, and development of informed conclusions without direct field data collection.

### Result and Discussion on Artificial Intelligence and Implementation of Science Education in Nigerian Tertiary Institutions.

Artificial intelligence (AI) has increasingly become a transformative tool in the implementation of science education within Nigerian tertiary institutions. Its contributions are evident in teaching, learning, research, and institutional management. The following are six detailed ways through which AI has enhanced science education implementation, supported with verified scholarly evidence.

#### Personalized Learning and Adaptive Instruction

One of the most significant contributions of AI to science education is its ability to provide personalized learning experiences. AI-powered systems analyze students' learning patterns, strengths, and weaknesses, thereby enabling lecturers to tailor instructional content to individual needs. This is particularly important in science education, where students often differ in their pace of understanding complex concepts such as physics, chemistry, and biology. Research has shown that AI supports

adaptive learning systems that cater to different learning styles and needs, improving comprehension and retention among students. Similarly, AI-driven platforms enhance individualized instruction, thereby improving learning outcomes and academic performance in tertiary institutions.

### **Enhancement of Teaching Methods and Instructional Delivery**

AI has introduced innovative teaching approaches that make science education more interactive and engaging. Through tools such as virtual laboratories, simulations, and intelligent tutoring systems, lecturers can demonstrate scientific concepts that may otherwise be difficult to explain using traditional methods. Edinoh, Salami and Nwafor indicate that AI promotes innovative teaching methods and improves instructional delivery in science-related courses. In addition, AI integration has been found to enhance pedagogical practices by supporting more effective teaching strategies and classroom engagement.

### **Improvement in Assessment and Evaluation Processes**

AI has significantly improved how students are assessed in science education. AI-based assessment tools enable automated grading, real-time feedback, and continuous evaluation of students' academic progress. This reduces the workload of lecturers while ensuring more objective and accurate assessment. Evidence from Nigerian studies shows that AI enhances assessment methods and supports effective evaluation of students' performance in tertiary institutions. Furthermore, AI-driven systems allow educators to monitor students' progress and provide timely interventions where necessary.

### **Support for Research and Data Analysis**

Science education in tertiary institutions heavily relies on research activities. AI has improved research implementation by providing tools for data collection, analysis, and interpretation. With AI, large datasets can be processed efficiently, enabling students and researchers to generate accurate scientific findings. Ogunode Agbade, and Basseyy reveal that AI facilitates research programmes and enhances the implementation of teaching and research activities in Nigerian tertiary institutions. In addition, AI-based data analytics tools support scientific investigations and innovation in higher education settings.

### **Promotion of Collaborative and Interactive Learning**

AI technologies encourage collaborative learning environments where students can engage in group-based problem-solving and knowledge sharing. AI-powered platforms enable students to interact with peers and instructors both physically and virtually, thereby fostering teamwork and a deeper understanding of scientific concepts [10]. Ogunode and Ukozor indicate that AI enhances collaborative learning and supports interactive engagement among students in tertiary institutions. This collaborative approach is particularly beneficial in science education, where experimentation and teamwork are essential components of learning.

### **Professional Development and Capacity Building for Lecturers**

AI has contributed to the professional growth of lecturers by providing access to modern teaching tools, digital resources, and continuous training opportunities. Through AI-driven platforms, lecturers can improve their instructional skills, update their knowledge, and adopt best practices in science education. Empirical studies highlight that AI supports professional development and enhances the productivity of academic staff in Nigerian tertiary institutions. This capacity building is crucial for the effective implementation of science education programmes in a technology-driven academic environment.

### **Challenges Militating against the development of AI and science Education**

Several challenges continue to hinder the effective development of Artificial Intelligence (AI) and science education, particularly in developing regions. One major issue is inadequate funding [12]. Many educational institutions lack the financial resources needed to build modern laboratories, acquire advanced technological tools, or maintain up-to-date learning environments. Without sufficient investment, it becomes difficult to provide students with practical exposure to AI systems, scientific experiments, and emerging innovations, all of which are essential for meaningful learning.

Another significant challenge is the shortage of qualified teachers and instructors. AI and science education require specialized knowledge and continuous professional development, yet many

educators are not adequately trained in these rapidly evolving fields. This gap leads to outdated teaching methods and limits students' ability to engage with current technologies. In some cases, teachers may feel intimidated by AI-related topics, which further reduces the quality of instruction and discourages student interest [13]. Poor infrastructure also plays a critical role in limiting progress. Reliable electricity, internet access, and modern classroom facilities are fundamental for teaching AI and science effectively. In many areas, especially rural communities, these basic requirements are inconsistent or entirely unavailable. As a result, students cannot access online resources, run simulations, or participate in digital learning platforms that are central to AI education [14].

Additionally, there is often a lack of relevant curriculum and educational policies that support AI and science development. Many school systems still rely on outdated syllabi that do not reflect current scientific advancements or the growing importance of AI. Without curriculum reform, students are not adequately prepared for modern careers or equipped with critical thinking and problem-solving skills necessary in today's technology-driven world. Socio-economic factors further compound these challenges. Students from low-income backgrounds may not have access to personal computers, smartphones, or internet connectivity, putting them at a disadvantage compared to their peers. This digital divide widens educational inequality and limits the pool of future scientists and AI professionals [15].

Finally, limited awareness and negative perceptions about AI and science can also slow development. In some communities, there may be misconceptions about AI replacing human jobs or a general lack of understanding of its benefits. This can reduce interest and support for science-related education, both from students and policymakers. Addressing these perceptions through awareness campaigns and inclusive education strategies is essential for fostering growth in the field.

## Conclusions

The study has demonstrated that artificial intelligence plays a vital role in enhancing the implementation of science education in Nigerian tertiary institutions. Through its application in personalized learning, instructional delivery, assessment, research, collaboration, and staff development, AI has contributed to improving the overall quality and effectiveness of science education. These advancements are particularly significant in addressing longstanding challenges such as inadequate teaching resources, limited laboratory facilities, and inefficient assessment systems.

The full potential of AI in science education has not yet been realized due to persistent challenges, including inadequate infrastructure, unstable power supply, insufficient funding, limited digital competencies among educators, and the absence of comprehensive policy frameworks. Despite these limitations, the growing adoption of AI signals a positive shift toward modernizing science education in Nigeria. Based on the findings, the study recommends the following:

- a. **Increased Investment in Infrastructure:** Government and institutional authorities should invest in digital infrastructure, including reliable internet connectivity, modern ICT facilities, and stable power supply, to support AI integration.
- b. **Capacity Building for Academic Staff:** Regular training programmes, workshops, and professional development initiatives should be organized to equip lecturers with the necessary skills to effectively utilize AI tools in science education.
- c. **Development of Clear Policy Frameworks:** The government should establish comprehensive policies and guidelines to regulate and promote the ethical and effective use of AI in tertiary education.
- d. **Integration of AI into Curriculum:** Tertiary institutions should incorporate AI-related content into science curricula to prepare students for emerging technological demands and enhance their digital competencies.
- e. **Strengthening Research and Collaboration:** Institutions should encourage research on AI applications in science education and foster collaborations with international organizations and technology firms.
- f. **Provision of Funding and Support:** Adequate funding should be allocated to support the acquisition and maintenance of AI technologies, as well as to promote innovation in science

education.

**Promotion of Public-Private Partnerships:** Collaboration between government, private sector, and educational institutions should be encouraged to facilitate access to AI tools and resources.

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