

APPLICATION OF ARTIFICIAL INTELLIGENCE IN THE TEACHING AND LEARNING OF BIOLOGY: IMPLICATIONS FOR SCIENTIFIC LITERACY AND NATIONAL DEVELOPMENT

REV. SR. METU GEORGIANA CHINYERE (PhD).
DEPARTMENT OF BIOLOGY.
SCHOOL OF SCIENCES
BENJAMIN UWAJUMOGU (STATE) COLLEGE OF EDUCATION,
IHITTE UBOMA, IMO STATE
08063965445 georgianametu@gmail.com

Abstract

Artificial Intelligence (AI) is increasingly reshaping educational practices across the globe. This study examined the application of AI in the teaching and learning of Biology in secondary schools within Owerri Municipal Council of Imo State, Nigeria, with particular emphasis on its implications for scientific literacy and national development. A mixed-methods research design was adopted, involving Biology teachers and senior secondary school students. Data were collected using questionnaires, interviews, and classroom observations. The findings revealed that AI-supported instructional strategies enhanced students' understanding of complex biological concepts, increased learner engagement, and improved critical thinking skills. However, challenges such as inadequate infrastructure, limited teacher training, unstable electricity supply, and insufficient policy support were identified. The study concludes that effective integration of AI into Biology education can significantly improve scientific literacy and contribute to sustainable national development. Recommendations were made for policymakers, school administrators, and educators to strengthen AI adoption in Nigerian secondary schools.

Keywords: Artificial Intelligence, Biology Education, Scientific Literacy, National Development, Teaching and Learning.

Introduction

Education remains a cornerstone for national development, serving as a means through which societies cultivate human capital, promote innovation, and achieve sustainable growth. In recent years, rapid advancements in digital technologies have transformed traditional educational systems, giving rise to more learner-centered and technology-driven instructional practices. Among these emerging technologies, Artificial Intelligence (AI) has gained considerable attention for its potential to improve teaching and learning processes.

Artificial Intelligence refers to the capability of computer systems to perform tasks that normally require human intelligence, such as reasoning, learning, problem-solving, and decision-making. In the context of education, AI is applied through intelligent tutoring systems, adaptive learning platforms, virtual laboratories, automated assessments, and learning analytics. These tools provide personalized learning experiences, immediate feedback, and opportunities for deeper conceptual understanding.

Biology, as a core science subject at the secondary school level in Nigeria, plays a critical role in fostering students' understanding of life processes, health education, environmental sustainability, and biotechnology. However, the teaching and learning of Biology in many secondary schools, including those in Owerri Municipal,

are often constrained by traditional instructional approaches that emphasize rote memorization rather than conceptual understanding. This situation has contributed to declining student interest, poor academic performance, and low levels of scientific literacy. It is also worthy to note that inability of teachers to use instructional methods bring about ineffective implementation; The technique used must be student-centered and activity-oriented and it must be research-based instruction that allows maximum student- to student interaction for learning purposes (Ezeh, Nwobodo, & Ishiwu, 2021). The use of multimodal representations e.g visual aids combined with text and experimental learning approaches significantly enhances retention and deep understanding of biology

The integration of AI into Biology education offers a promising pathway for addressing these challenges. By supporting interactive and personalized learning, AI has the potential to enhance students' scientific literacy and prepare them to contribute meaningfully to national development. Scientific literacy has become an essential goal of science education in the modern world. It enables individuals to understand scientific concepts, apply scientific reasoning, and make informed decisions in their personal and professional lives. In developing countries such as Nigeria, scientific literacy is particularly important for addressing national challenges related to health, agriculture, environmental management, and technological advancement.

Despite the recognized importance of Biology education, many Nigerian secondary school students continue to struggle with the subject. Research has shown that abstract biological concepts, lack of instructional resources, and teacher-centered pedagogical practices hinder effective learning. In Owerri Municipal, secondary schools face additional challenges such as overcrowded classrooms, inadequate laboratory facilities, and limited access to modern educational technologies. Challenges of secondary school education in Nigeria as poor funding, overcrowded classroom, dilapidated school facilities. (Ihebom & Uko, 2020).

Artificial Intelligence provides innovative solutions that can support Biology teaching by offering virtual simulations, interactive models, and adaptive instructional content. These tools allow students to visualize complex processes such as photosynthesis, genetics, cell division, and ecological interactions. Consequently, the application of AI in Biology education may significantly enhance students' understanding and promote scientific literacy.

Many schools in the region lack modern laboratory equipment, making it difficult for students to conduct necessary experiments; Artificial Intelligence based learning tools offer potential solutions to these challenges by providing interactive simulations, virtual biology laboratories, artificial intelligence-driven tutoring, and real-time performance tracking. (Ozioko, Shu'aibu, & Ugwu 2025). Artificial Intelligence tools effectively visualize abstract biological processes like DNA replication, cellular respiration and photosynthesis.

Artificial Intelligence has been widely adopted in education to support personalized and adaptive learning experiences. AI-driven systems adjust instructional content based on learners' abilities, pace, and learning preferences, thereby improving learning outcomes. Integrating artificial intelligence in teaching science in Nigeria is not just about improving educational procedures, but also about strategically equipping students for a future where science, technology, and innovation play a crucial role in social advancement and wealth.(Okunade, 2024).

Nigeria can cultivate a cohort of students that has expertise in both conventional scientific ideas and advanced technology by integrating artificial intelligence into science education (Okunade, 2024). Artificial Intelligence (AI) is the replication of human intelligence in robots that are intended to mimic human thinking and learning. (Fayzullina, Filippova, Garnova, Astakhov, Kalmazova, & Zaripova, 2025).

Biology education requires visualization, experimentation, and inquiry-based learning. Traditional lecture methods often fail to address these requirements, resulting in poor conceptual understanding and

misconceptions among students.

Research has shown that provision and use of instructional media, use of innovative instructional methods among other things are factors that could affect the implementation of every curriculum including that of biology curriculum (Ezeh, Nwobodo, & Ishiwu 2021) . Evidence suggests that these tools aid in mastering complex concepts, though effective implementation requires addressing teacher preparation, technical infrastructure, and ethical concerns.

Practical work stimulates learner interest in the science subject they are studying, when they are made to personally engage in useful activities; knowledge obtained through practical work and experience, promote long term memory that theory alone cannot do (Ngakhala, 2021).

Scientific literacy enables individuals to engage critically with scientific issues and contribute to socio-economic development. Nations that prioritize science education tend to experience higher levels of innovation and technological growth.

In order for the developed nations of the world to flow with the tide of scientific and technological transition, conscious effort have been made to structure their resources to the development and engagement of scientific literate citizens. (Aderonmu, & Telima, 2021). In Nigeria, a major goal of science education is to produce scientists who will fit into the world's national development. The vision of every scientific community is the development of scientific literacy of the learners to proffer solutions to compelling scientific demands that is confronted in our everyday engagements; Acquisition of scientific literacy is a yardstick for societal development (Aderonmu,& Telima, 2021).

This study is anchored on the Constructivist Learning Theory, Jean Piaget(1896-1980) which emphasizes that learners actively construct knowledge through interaction and experience. Albased instructional tools support constructivist learning by enabling exploration, collaboration, and personalized learning pathways. Constructive learning Theory is highly relevant to the use of Artificial Intelligence (AI) in the teaching and learning of biology because both emphasize active learner- centered learning.

Statement of the Problem

Despite the growing relevance of AI in education globally, its application in secondary school Biology instruction in Owerri Municipal remains limited. Most schools still rely heavily on conventional teaching methods that do not adequately support student engagement or conceptual understanding. As a result, students often perceive Biology as difficult and abstract, leading to low achievement and reduced interest in science-related careers.

Furthermore, many Biology teachers lack the necessary training and confidence to integrate Albased instructional tools into their teaching practices. Infrastructural challenges, such as poor Internet connectivity and unreliable electricity supply, further limit the effective adoption of AI in schools. This study therefore seeks to examine the application of Artificial Intelligence in the teaching and learning of Biology in secondary schools within Owerri Municipal and its implications for scientific literacy and national development.

Purpose of the Study

The main purpose of this study was to investigate the application of Artificial Intelligence in the teaching and learning of Biology in secondary schools in Owerri Municipal.

The study was guided by the following specific objectives:

To determine the extent to which AI tools are used in teaching and learning Biology in secondary schools in Owerri Municipal.

To examine the influence of AI-based instruction on students' scientific literacy.

To identify challenges associated with the application of AI in Biology education.

Research Questions

Are AI tools used in the teaching and learning of Biology in secondary schools in Owerri Municipal?

How does the use of AI influence students' scientific literacy?

What challenges hinder the effective application of AI in Biology teaching and learning?

METHODOLOGY

A mixed-methods research design was adopted, combining quantitative and qualitative approaches, questionnaire and interview.

The study was conducted in selected secondary schools within Owerri Municipal Council of Imo State, Nigeria. The population comprised all 6,347 Biology senior secondary school students and 55 biology teachers in Owerri Municipal. A purposive sample of 20 Biology teachers and 635 SS2 students was selected.

Data were collected using structured questionnaires. Quantitative data were analyzed using descriptive statistics, while qualitative data were analyzed using inferential statistics.

RESULTS

The results of data analysis are presented in Tables and interpreted according to the specific purpose of study and research questions.

Table 1: Mean responses of teachers on the extent to which AI tools are used in teaching and Learning biology.

The result in Table 1 shows that the grand mean of 2.82 indicates that teachers agreed that AI tools are used in teaching and learning Biology. Specifically, they agreed that AI tools are used in teaching Biology. AI tools help in explaining topics better used in preparing lessons or instructional materials, and used in assessing students. The result shows that AI tools are utilized to a moderate extent.

Table 2: Mean responses of teachers on the influence of AI instruction on teachers' scientific literacy.

The result in Table 2 shows that the grand mean of 2.97 indicates that teachers agreed that AI instruction positively influences students' scientific literacy. Specifically, they agreed that AI-based instruction helps students understand scientific ideas better, encourages them to ask more scientific questions, improves their ability to think scientifically, and helps them apply biology knowledge to real-life problems, indicating a positive influence of AI instruction on scientific literacy.

Table 3: Mean responses of teachers on the challenges associated with the use of AI application in biology education.

S/N Items SA A D SD Total Mean SD Remarks

I lack adequate training 35 20 0 0 55 3.64 0.453 Agree

to use AI tools in teaching Biology

There is limited access 30 25 0 0 55 3.55 0.464 Agree to AI tools and facilities in my school

Poor internet or power 30 15 5 5 55 3.27 0.971 Agree

supply affects the use of AI in biology lessons

Time constraints made 20 25 5 5 55 3.09 0.903 Agree it difficult to use AI

tools during biology classes

Grand Mean 3.38 0.697 Agree

The result in Table 3 shows that the grand mean of 3.38 indicates that teachers agreed that there are significant challenges associated with the use of AI applications in Biology education. Specifically, they agreed that they lack adequate training to use AI tools, there is limited access to AI tools and facilities in their schools, poor internet or power supply affects usage, and time constraints make it difficult to use AI tools during Biology classes, indicating that these challenges substantially hinder effective AI integration.

Discussion of Findings

Research question 1 focused on the extent to which Artificial Intelligence tools are used in teaching and learning.

The result shows that AI tools help biology teachers regularly in explaining biology topics better. AI tools are also used in preparing lessons or instructional materials and accessing students. This finding is in agreement with Fayzullina, Filippova, Garnova, Astakhov, Kalmazova, & Zaripova, (2025), that Artificial Intelligence (AI) is the replication of human intelligence in robots that are intended to mimic human thinking and learning.

Research question 2 focused on the influence of AI instruction on teachers scientific literacy. The result shows that the respondents agreed that AI-based instruction helps students understand scientific ideas better, encourages them to ask more scientific questions, improves their ability to think scientifically, and helps them apply biology knowledge to real-life problems. This finding is in agreement with Aderonmu & Telima

(2025). The vision of every scientific community is the development of scientific literacy of the learners to proffer solutions to compelling scientific demands that is confronted in our everyday engagements; Acquisition of scientific literacy is a yardstick for scientific development .

Research question 3 focused on the challenges associated with the use of AI application in biology education. The result shows that the respondents agreed that they lack adequate training to use AI tools, there is limited access to AI tools and facilities in their schools, poor internet or power supply affects usage, and time constraints make it difficult to use AI tools during Biology classes. This findings is in agreement with Ezeh, Nwobodo, Ishiwu (2021). Research has shown that provision and use of instructional media, use of innovative instructional methods among other things are factors that could affect the implementation of every curriculum including that of biology curriculum.

Recommendations

Based on the findings of the study, the following recommendations are made:

Biology teachers should be trained on the use of AI tools in instruction. This will enhance regular use of AI tools by biology teachers in instructional delivery.

Students should use AI tools to find the meaning of scientific terms to enhance scientific literacy. This will boost students vocabulary on scientific terms so that they can practice it in their daily lives.

School authority should provide AI tools in addition to training biology teachers in AI tools for instructional delivery. Source of power should be provided with internet facilities to facilitate the use of AI by students and teachers in learning biology.

Conclusions

The application of Artificial Intelligence (AI) in the teaching and learning of Biology has shown great promise in improving how students understand scientific concepts. AI tools make lessons more interactive, practical, and learner-centered. They help students visualize complex biological processes, receive instant feedback, and learn at their own pace. This improves understanding, critical thinking, problem-solving skills, and overall scientific literacy.

When students are scientifically literate, they are better able to make informed decisions about health, environment, and technology. They can apply biological knowledge to real-life situations and contribute meaningfully to society. For teachers, AI provides support in lesson planning, assessment, and identifying students' learning needs, making teaching more effective.

In the context of national development, especially in developing countries like Nigeria, integrating AI into Biology education can help produce skilled, innovative, and technologically competent citizens. These individuals can contribute to advancements in healthcare, agriculture, environmental management, and biotechnology.

Therefore, the effective and responsible use of AI in Biology education is not just an educational improvement, but a strategic step toward strengthening scientific literacy and promoting sustainable national development.

In summary:

Artificial Intelligence has significant potential to transform Biology education in secondary schools in Owerri Municipal.

AI tools are used by biology teachers in Owerri municipal regularly to explain biological concepts.

AI assisted instruction enhance the development of scientific literacy.

Problems associated with the use of AI for instruction in biology include lack of steady power supply, poor internet facilities and poor motivation of teachers to use AI tools.

References

- Aderonmu, S. B., & Telima, A. (2021). Students Level of Scientific Literacy and Academic Performance in physics Concepts in River State, Nigeria. *International Journal of Research and Innovation in Applied Science (URIAS)*. Vol. VI Page 1-4 Issue 1 ISSN 2454-6194
- Ezeh, O. V., Nwobodo, D., & Ishiwu, I. U. (2021). Extent of Implementation of Biology Curriculum in Senior Secondary Schools in Nssuka and Obollo-Afor Education Zones of Enugu State, Nigeria. *British International Journal of Education and Social Sciences*. Vol 8(7) Page 13-18 ISSN(3342-543x);P-ISSN(4519-6511)
Impact factor: 8.11

- Fayzullina, A. R., Filippova, A. A., Garnova, N. Y., Astakhov, D. V., Kalmazova, N., & Zaripova, Z. F., (2025). Artificial Intelligence in Science Education : A systematic Review of Applications , Impacts and Challenges in Contemporary Education Technology, 17 (4), ep613: <http://doi.org/10.30935/cedtech/17519>.
- Ihebom, B., & Uko, J. O., (2020). Challenges and Prospects of Sec. Education in Nigeria. International Journal of Scientific Research in Education 13(4), 670-688.
- Ozioko, M. O., Shu'aibu, I., & Ugwu , B. A., (2025). Artificial Intelligence as Emerging Tools in Teaching and Learning of Biology in Senior Secondary Schools in Gumel Local Government Area , Jigawa State. African Journal of Science, Technology and Mathematics Education. Vol.2, Issue 2, page 257-263. <https://www.ajstme.com.ng>.
- Ngakhala, J. N., (2021). Effects of Students Exposure to Biology Practicals on Performance in Public Secondary Schools in Lugari Sub country, Kakamega county, Kenya. International journal of interdisciplinary Research and Innovations V.9 issue 4, page 23-33 Okunade, A. I., (2024). The Role of Artificial Intelligence in Teaching of Science Education in Secondary Schools in Nigeria, European Journal of Computer Science and Information Technology. 12(1), page 57-67. Print ISSN: 2057-0957, Online ISSN:2054-0965, doi: <https://doi.org/10.37745/ejcsit.2013/vol12n15767>