

CHATGPT-ASSISTED LEARNING IN SECONDARY SCHOOL BIOLOGY EDUCATION: OPPORTUNITIES, CHALLENGES, AND BEST PRACTICES

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Abstract

The integration of Artificial Intelligence (AI) into education has transformed instructional practices by creating more personalized, interactive, and learner-centered learning experiences. Among emerging AI technologies, ChatGPT has attracted considerable attention for its potential to support students' understanding of complex concepts through instant feedback, adaptive explanations, and continuous academic support. This paper examined the role of ChatGPT-assisted learning in enhancing biology learning among secondary school students in Edo State, Nigeria. The study adopted an exploratory and expository research approach based on a systematic review of relevant scholarly literature obtained from journal articles, conference papers, research reports, and other academic publications accessed through databases such as Google Scholar and ResearchGate. The reviewed literature suggested that ChatGPT has potential to support students' conceptual understanding, self-regulated learning, inquiry-based learning and academic engagement when appropriately integrated into Biology instruction. The review also identified several challenges associated with its use, including the possibility of inaccurate information, academic dishonesty, overdependence on AI, inadequate digital infrastructure, limited teacher competence, and unequal access to technological resources. The paper concluded that ChatGPT should not replace teachers but should be integrated as a complementary instructional platform that enriches conventional classroom teaching.

Keywords: Artificial Intelligence, Biology Education, ChatGPT-Assisted Learning, School Students, Secondary

Introduction

Science education, as a core discipline within science pedagogy, serves as a fundamental catalyst for scientific innovation, technological advancement, and sustainable national development. It plays a vital role in preparing learners to understand the natural world, develop scientific literacy, and contribute meaningfully to societal development. It encompasses a systematically organized corpus of knowledge that emphasizes scientific concepts and technological content. This academic and practical field focuses on the methodologies of teaching, learning, and evaluating scientific knowledge, processes, and the nature of science itself (Obialor, 2018). A distinctive feature of science education is its role in cultivating critical thinking and problem-solving skills essential for interpreting ethical issues and scientifically-based assertions (Greenfield et al., 2024). At the senior secondary school level in Nigeria, science education primarily comprises three core disciplines: physics, chemistry, and biology. Within the secondary school science curriculum, biology occupies a central position because it equips learners with knowledge and skills necessary for understanding living organisms, environmental sustainability, biotechnology, genetics, health sciences, and emerging biological innovations. It plays a significant role in developing scientifically literate citizens who can understand biological processes, address environmental challenges, and contribute meaningfully to health, agriculture,

biotechnology, and sustainable development. The instructional goals of biology education involve equipping students with foundational biological knowledge, fostering scientific competencies including observation, experimentation, and critical analysis, and cultivating an appreciation of biodiversity (Federal Republic of Nigeria (FRN), 2013). It is a uniquely demanding discipline that combines abstract theoretical concepts, extensive scientific terminology, and microscopic processes that are often difficult for students to visualize without practical demonstrations and appropriate instructional materials (Mnguni & Moyo, 2021; Indah & Fadilah, 2024). Particularly the concept of the cell.

Owing to the abstract and microscopic nature of cells, students often find it difficult to understand and internalize cellular concepts at a deeper level (Widiastuti, 2024). Many Nigerian secondary schools continue to face significant challenges in teaching and learning biology effectively. Overcrowded classrooms, inadequate instructional and laboratory resources, and the continued reliance on conventional teacher-centered instructional approaches which often restrict students' active participation in learning, thereby limiting conceptual understanding (Ogegbo, 2021; Owolade et al., 2022). These constraints reduce opportunities for students to explore biological concepts through interactive discussions, practical investigations, and timely feedback, which are essential for developing meaningful conceptual understanding. As they are not only expected to passively receive information but also to actively explore, create, and self-evaluate in their learning (Ntaila, 2023). By embracing interactive and engaging learning media, students are more likely to understand concepts better, stay motivated, and develop a deeper understanding of the subject matter. Hence the integration of Artificial Intelligence (AI) tools into science pedagogy, particularly, the teaching and learning of biology becomes imperative.

Artificial intelligence (AI) tools are valuable resources for creating more engaging, flexible, and learner-centered learning environments (Albadarin et al., 2024; Mai et al., 2024). Unlike conventional educational technologies that mainly deliver learning content, AI systems can interact with learners, answer questions, generate explanations, provide immediate feedback, create learning activities, and adapt responses to meet learners' individual needs. These AI tools have created new possibilities for addressing some of these instructional challenges. One of the most notable AI innovations in education is ChatGPT.

As a learning tool, ChatGPT could support students by explaining difficult concepts in simple and adaptive ways, answering questions instantly, and generating learning materials that complement classroom instruction. Recent studies have shown that ChatGPT creates valuable opportunities for education by providing immediate feedback, supporting personalized learning based on students' individual needs, and reducing the time and efforts teachers spend preparing instructional resources. When thoughtfully integrated into classroom practice, ChatGPT can enrich the teaching and learning process and contribute to improved students' understanding and academic achievement (Mulyati et al. 2022; Baig, 2024). In Biology, ChatGPT offers several opportunities to enrich students' learning experiences. It can simplify difficult concepts, provide step-by-step explanations of biological processes, generate practical questions, support laboratory preparation, facilitate revision, and encourage inquiry-based learning. Its conversational nature enables learners to ask questions freely, receive instant explanations, and engage with educational content beyond the traditional classroom setting (Albadarin et al., 2024). Research carried out in one junior high school showed that the use of monotonous learning media causes students to tend to be passive and boredom increases, therefore, learning media are needed that not only convey content, but also facilitate active student involvement, creativity, and evaluation that is relevant to their learning style (Sari et al. 2025).

Although growing literature has examined ChatGPT in higher education and general educational contexts, limited empirical evidence exists concerning its application to secondary Biology in Nigeria. More specifically, there is insufficient evidence regarding whether structured ChatGPT-assisted Biology instruction improves students' academic achievement, retention, conceptual understanding, scientific inquiry skills and attitudes towards Biology. There is also limited evidence concerning how teachers and students in Nigerian secondary schools perceive the ethical, pedagogical and practical implications of using generative AI in Biology classrooms. Much of the existing research on this subject either addresses AI adoption in education broadly (Baidoo-anu & Ansah, 2023; Adeshola & Adepoju, 2024) or examines subject areas other than Biology, such as English language instruction (De Simone et al., 2024). This gap is significant given Biology's distinctive instructional demands and its centrality to students' pathways into health and life sciences at the tertiary level. It is against this backdrop that the present paper investigates the role of ChatGPT-assisted learning in enhancing the effective learning of biology among secondary school students in Edo State. Specifically, the paper examined: (i) the role of artificial intelligence in education; (ii) the concept and application of ChatGPT to Biology learning; (iii) the potential contributions of ChatGPT to Biology learning; (iv) the challenges associated with the use of ChatGPT-assisted learning in biology; and (v) best practices for integrating ChatGPT into secondary school Biology instruction.

Theoretical Framework

This study was anchored on constructivism learning theory posited in 1952 by Jean Piaget. It holds that learners actively construct knowledge rather than passively receive information. Learning occurs as learners interact with new experiences and integrate them with their existing cognitive structures or prior knowledge (Piaget, 1952; Schunk, 2020). It assumes that learning is built upon prior knowledge and experiences, which learners use as a foundation for interpreting and integrating new information. This cognitive constructivism, advanced by Jean Piaget, explains that learning occurs as individuals modify their cognitive structures through the processes of assimilation and accommodation when confronted with new experiences. It emphasizes student-centered learning, where teachers guide rather than direct, fostering deep understanding and application. The learner evaluates his or her knowledge in light of what he or she encounters in the new learning environment.

Constructivist learning theory supports ChatGPT-assisted learning by allowing students to ask questions at their own pace, build understanding through continuous dialogue, explore biological concepts using explanations suited to their level, correct misconceptions through immediate feedback, learn independently beyond the classroom, rather than memorizing biology facts.

Methods

This study adopted an exploratory and expository research approach to obtain relevant information on the use of ChatGPT-assisted learning. Data were gathered from secondary sources, including published journal articles, research reports, conference papers, and other scholarly literature focusing on the roles of ChatGPT in teaching and learning of biology, the challenges associated with the use of ChatGPT and the effective ways of integrating ChatGPT into the teaching of biology, particularly within the Nigerian context. Over a period of six weeks, the researcher engaged in narrative/integrative literature review from academic databases such as

Google Scholar and ResearchGate. The retrieved materials were carefully examined, synthesized, and analyzed to provide a comprehensive review of existing evidence on the subject.

The Role of Artificial Intelligence in Education

The field of education especially lends itself to AI technologies since educational activities, including learning and teaching, are knowledge-intensive cognitive activities, and AI applications, which are created for cognition and problem-solving based on algorithms and knowledge base, can effectively support and augment educators' and learners' abilities in teaching and learning. Since its emergence in the mid-1950s, artificial intelligence (AI) has evolved from a theoretical field into a transformative technology that is increasingly being integrated into education to enhance teaching and learning across disciplines, including language education, STEM, and medicine (Russell & Norvig, 2021; Zawacki-Richter et al., 2021). Numerous applications of AI in education have emerged. For example, Khan Academy offers Khanmigo, Duolingo Max, Quizlet AI, Google Gemini, Pi AI, an AI tutor harnessing GPT-4 capabilities, and Open AI (ChatGPT) delivering personalized learning support and intelligent feedback across various subjects, including mathematics, programming, and language learning. Similarly, Duolingo, a language learning platform and ChatGPT, uses sophisticated AI systems to improve learner experiences (Bicknell et al., 2023). AI tools such as ChatGPT could foster self-regulated learning by enabling learners to plan study activities, monitor understanding, and adjust learning strategies through continuous interaction.

Concept of ChatGPT-assisted Learning in Learning Biology

ChatGPT-assisted learning is the integration of ChatGPT into the teaching and learning process to support students' learning through personalized guidance, interactive dialogue, immediate feedback, content generation, and adaptive learning experiences that enhance understanding and academic performance. With the education sector emerging as one of the key areas benefitting from its growing adoption. It has brought significant changes to educational curricula, particularly in the fields of science, technology, engineering, and mathematics (STEM) where it is transforming both teaching practices and students' learning experiences. In November 2022, Open AI released a programme called ChatGPT that makes use of artificial intelligence (Sharma & Yadav, 2022). It is a generative artificial intelligence (AI) chatbot, designed to understand natural language, engage in human-like conversations, answer questions, generate text, and assist users with a wide variety of tasks. It works by using a large language model (LLM) that has been trained on vast amounts of text to recognize patterns in language, which enable it to brainstorm ideas and solve problems, assist with coding and data analysis, summarize and translate text, and as well answer questions and explain concepts. Students can benefit from ChatGPT as a learning support tool because it provides instant feedback, facilitates inquiry-based learning, and encourages active engagement with academic content (Rudolph et al., 2023). ChatGPT can also enhance learning by generating educational content, personalizing learning experiences, supporting problem-solving, providing timely feedback, and improving student engagement when integrated appropriately into teaching and learning. Additionally, it offers considerable potential for enhancing biology learning by supporting personalized instruction, active engagement, and conceptual understanding.

Biology as a Core Science Subject

As a core science subject in secondary school, biology covers a broad range of topics related to the study of living organism and their interactions with the environment. As a foundational discipline, it equips students with scientific knowledge and skills that are essential for understanding life processes and addressing real-world challenges. The integration of ChatGPT into biology learning represents a significant advancement in personalized learning, offering students adaptive support, immediate feedback, and interactive learning experiences that can enhance their understanding of biological concepts and as well enhance the understanding of intricate topics such as genetics, cellular biology, and ecology (Liu et al., 2023). Its ability to engage students in detailed conversations enable them to explore biological concepts more deeply at their own pace, thereby fostering a personalized and learner-centered educational experience. (Ng et al., 2023). The integration of ChatGPT into biology learning has the potential to foster a more engaging and interactive learning environment while providing a more efficient and effective approach to mastering the biological concepts, thereby contributing to improved academic achievement.

The Role of Chatgpt-Assisted Learning in Enhancing Effective Learning of Biology Students

The importance of ChatGPT-assisted learning in education lies in its ability to complement traditional classroom instruction by promoting self-regulated learning, facilitating higher-order thinking, and supporting knowledge construction (Lee et al., 2024). Through immediate feedback, tailored explanations, and continuous academic support, ChatGPT enables students to learn at their own pace and engage more meaningfully with course content in ways that accommodate their individual learning needs. It creates a more interactive and supportive learning environment that makes meaningful engagement with learning more accessible, thereby enhancing students' academic experiences and overall learning effectiveness (Schönberger, 2024). Furthermore, ChatGPT has the potential to support learning processes by enabling students to set learning goals, seek clarification when they encounter difficulties in understanding, and deepen their knowledge through reflective questioning (Lee et al., 2024). It does not substitute for learners' cognitive effort, rather it serves as a scaffold that supports the development of self-regulated learning and greater learner autonomy (Ng et al., 2024). Using ChatGPT as a learning aid can help students feel more supported and connected throughout their academic journey. Although it cannot replace the meaningful interactions students have with teachers and classmates, ChatGPT provides immediate guidance, answer questions and offer continuous support whenever it is needed. This consistent availability can reduce feelings of isolation, particularly during independent study, and give students greater confidence in their learning. As a result, students may become more motivated to participate in learning activities because they feel supported and encouraged, fostering a stronger sense of connection and belonging within the learning environment.

Challenges Associated with the Use of ChatGPT Among Secondary School Students

Despite the numerous benefits offered by language models such as ChatGPT, they also present several challenges (Brown, et al., 2020). These challenges may affect their effective adoption and use in educational settings. The major challenges associated with the use of ChatGPT in education are 1. Pedagogical challenges such as overdependence, reduced independent thinking. 2. Ethical challenges such as plagiarism, academic dishonesty, authorship. 3. Epistemic challenges such as hallucinations, inaccurate information, fabricated references. 4. Technological challenges such as internet access, electricity, devices, teacher-related challenge,

AI literacy, and professional development. the possibility of generating inaccurate, misleading, or outdated information. Since ChatGPT produces responses based on patterns learned from large datasets rather than independently verifying facts, the information it provides may not always be reliable. ChatGPT draws on information derived from internet-based databases and publications, which may contain both accurate and inaccurate content. Consequently, students who rely on ChatGPT without critically evaluating its responses risk incorporating false or misleading information into their academic work, thereby compromising the quality and credibility of their learning outcomes (UNESCO, 2023). Also, the excessive dependence on ChatGPT for explanations, problem-solving, and assignment completion may limit opportunities for classroom discussion, collaborative learning, and direct engagement with teachers. The growing integration of artificial intelligence into education may negatively influence students' communication skills and reduce the quality of interactions that are essential for meaningful learning and social development (García-Peñalvo et al. 2024). Moreover, ChatGPT may generate fabricated or inaccurate references and citations that appear authentic, posing a challenge to students who rely on AI-generated information without verification (Zhan, Xu, & Sarkadi, 2023).

Best practices for Using ChatGPT in Learning Biology

Students should regard ChatGPT as a tool that supports learning rather than a substitute for studying or independent thinking. Instead of asking the AI to complete assignments or provide direct answers to examination questions, learners should use it to explain concepts, provide examples, and guide their understanding. Moreover, secondary school students should actively verify the accuracy of information generated by ChatGPT by critically evaluating its responses, cross-checking biological facts with reliable scientific sources, and applying scientific reasoning to ensure accurate understanding of biological concepts (Agarwal et al., 2023).

Also, Biology comprises numerous abstract concepts and complex biological processes that often present learning difficulties for students. ChatGPT can support conceptual understanding by simplifying scientific explanations, providing relevant examples, and presenting information at a varying level of complexities to meet individual learning needs. To enhance meaningful learning of biology, secondary school students should critically examine and validate ChatGPT-generated outputs before incorporating them into their learning activities (Hariri, 2023). Although ChatGPT can explain experimental procedures, biological mechanisms, and scientific concepts, it cannot substitute for laboratory experiments, field investigations and other experiential learning activities. Effective biology education requires a balanced integration of theoretical knowledge and practical experience. Students should therefore use ChatGPT to prepare for practical lessons, interpret experimental findings, and reinforce theoretical concepts acquired through practical engagement. Such integration contributes a more holistic understanding of biology and strengthens the connection between scientific theory and practice. Many researchers have cautioned that overreliance on AI (ChatGPT) may hinder intellectual development and encourage unethical academic practices (Kamoun et al., 2023; Kasneci et al., 2023). Therefore, the educational use of ChatGPT should be guided by the principles of honesty, responsibility and ethical scholarship. Students should avoid presenting AI-generated responses as their original work or using the tool to engage in academic misconduct. Instead ChatGPT should be employed as a learning aid that supports idea generation, concept clarification, and knowledge acquisition while students produce their own original academic work. Adherence to academic integrity not only preserves educational standards but also fosters intellectual growth and authentic learning.

While ChatGPT offers significant educational benefits, excessive dependence on AI may hinder the development of independent learning skills. Students should therefore adopt a balanced approach by combining AI-assisted learning with classroom instruction, independent study, collaborative learning, practical activities, and consultation with teachers. Such an approach encourages self-regulated learning, strengthens problem-solving abilities, and enhances students' capacity to apply biological knowledge effectively in both academic and real-life contexts.

Conclusion

ChatGPT-assisted learning presents valuable opportunities for enhancing biology education by promoting personalized learning, improving students' understanding of biological concepts, and supporting learner-centered instruction. However, challenges such as academic dishonesty, misinformation, and limited teacher competence must be addressed. Rather than replacing teachers, ChatGPT should serve as a complementary instructional tool supported by appropriate pedagogical practices, ethical guidelines, and adequate technological infrastructure. When integrated responsibly, ChatGPT should function as a teacher-guided cognitive and instructional support tool fostering independent learning, and strengthen biology education among secondary school students.

Suggestions

Based on the findings of this review, the following suggestions are made:

1. Clear ethical guidelines should be developed for the educational use of ChatGPT. Schools should establish policies that promote responsible AI use, discourage plagiarism and academic dishonesty, and encourage students to use ChatGPT as a learning support tool rather than a substitute for independent thinking and original work.
2. Students should be encouraged to verify AI-generated information. Since ChatGPT may occasionally generate inaccurate or outdated responses, learners should be guided to cross-check information using approved biology textbooks, peer-reviewed literature, and their teachers' professional guidance before accepting AI-generated content.
3. ChatGPT should be integrated with practical biology activities. AI-assisted learning should complement rather than replace laboratory experiments, fieldwork, demonstrations, and other hands-on learning experiences that are essential for developing scientific process skills and meaningful conceptual understanding.
4. Further empirical studies should be conducted. Future researchers should investigate the actual effects of ChatGPT-assisted learning on students' academic achievement, retention, motivation, critical thinking, and scientific inquiry skills using experimental, quasi-experimental, and mixed-methods research designs across different educational settings in Nigeria.
5. Students should adopt a balanced learning approach. While ChatGPT offers valuable academic support, students should combine its use with classroom learning, independent study, collaborative learning, consultation with teachers, and practical experiences to develop deeper understanding, critical thinking, and long-term academic competence.
6. Biology teachers should integrate ChatGPT into careful designed learning activities that require students to verify AI-generated explanations, compare AI responses with scientific sources, and apply knowledge to practical problems.

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