



Correlation Between Integration of Artificial Intelligence-Assisted Instruction and Self-Efficacy in Biology Teaching and Learning among Secondary School Students in Gusau, Zamfara State

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Abstract

This study investigated Correlation between integration of Artificial Intelligence (AI)-assisted instruction and Biology students' self-efficacy among on secondary schools in Gusau metropolis, Zamfara State. The population comprised all private senior secondary school biology students in the study area who utilize AI tools for academic purposes. A sample of 313 students was selected using a purposive sampling technique. The study was guided by two research objectives, two research questions, and two null hypotheses. A descriptive survey research design was adopted for the study. Data was collected using an instrument titled "Biology Students AI and Self-Efficacy Questionnaire" (BSASEQ). The instrument was validated by experts and pilot-tested, yielding a reliability coefficient of 0.75. The research questions were analyzed using descriptive statistics (Mean and Standard Deviation), and the null hypotheses were tested at the 0.05 level of significance using Pearson Product-Moment Correlation Coefficient and an independent samples t-test. The findings revealed that variations in AI usage do not correspond with changes in students' self-efficacy levels in biology and no significant gender differences in self-efficacy were found. The study recommends that comprehensive AI literacy courses describing the functional mechanics, ethics, and practical applications of AI should be integrated into educational institutions to optimize technological adoption.

Keywords: Artificial Intelligence, AI-Assisted Instruction, Self-Efficacy, Secondary Education.

Introduction

Artificial Intelligence (AI) has the capacity to improve student engagement and comprehension by automating administrative activities, personalizing learning experiences, and providing real-time feedback (Holmes et al., 2019). When AI is integrated into education, individual variances can be accommodated. AI is especially helpful in addressing individual learning demands and encouraging self-directed learning in secondary education settings (Zawacki-Richter et al., 2019), allowing students to learn at their own pace. Students can experience individualized, engaging, and immersive learning through AI-based solutions, including virtual labs, AI-assisted tutoring, and interactive simulations (Chen et al., 2018). To ensure that future citizens can not only utilize AI technologies but also interact with them critically, ethically, and artistically, international organizations like UNESCO and the World Economic Forum have urged the integration of AI capabilities into national curricula (Milberg, 2024; UNESCO, 2023b). These advancements show that AI literacy—the capacity to recognize, comprehend, assess, and ethically use AI technologies—is emerging as a crucial 21st-century talent and a primary educational priority (Hossain, 2025a; Voulgari et al., 2022).

AI literacy goes beyond basic technological expertise to include ethical and cognitive aspects, such as contextual awareness, data integrity, transparency, and responsible use (UNESCO, 2023a;



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Voulgari et al., 2022). In the context of algorithmic systems and machine-generated content, AI literacy can be seen as an advancement of well-established information literacy paradigms, extending conventional abilities of finding, assessing, and using information ethically. More academics contend that fostering such literacy encourages critical agency, optimism about AI's role in society, and technology fluency (Hollands & Breazeal, 2024). A rising number of international organizations have advocated for the inclusion of AI literacy skills in national curricula. This aligns with the World Economic Forum's recommendation to integrate AI into education to produce workers who can interact critically with new technology (Milberg, 2024). In a similar vein, the Organization for Economic Co-operation and Development (OECD, 2025) intends to incorporate Media and Artificial Intelligence Literacy (MAIL) into the Program for International Student Assessment (PISA), indicating a rising global acknowledgement of AI competency. Recent studies highlight the necessity of integrating AI literacy into educational settings. According to Hornberger et al. (2023) and Milberg (2024), students expect AI to be a major part of their future employment, even though many of them already use AI technologies daily. According to Williams (2024), AI literacy is a fundamental ability at all educational levels. In line with this, Hossain (2025a) encourages students to interact critically, morally, and responsibly with AI technology by promoting the development of critical AI literacy and AI citizenship. Studies have also shown that teachers' preparedness and skills play a major role in how well AI is integrated into classrooms. Teachers must acquire AI competencies to promote 21st-century skills and provide an example of appropriate AI engagement (Khazanchi & Khazanchi, 2025; Hossain et al., 2024). Consequently, teacher training programs need to be reviewed to accommodate AI. According to Su et al. (2023), there are substantial gaps in instructors' understanding of AI, curriculum design constraints, and a lack of pedagogical standards. Many instructors lack the conceptual knowledge required to teach with or about AI. These results highlight the need for institutional support and professional development to enable instructors to facilitate AI literacy. The advancement of AI instruction in education has transformed the way students interact with technological tools, creating distinct psychological dimensions related to technology reliance, adaptivity, and self-efficacy. Self-efficacy refers to one's confidence in their ability to use AI tools effectively (Morales-Garcia et al., 2025). This variable can influence technological dependence, thereby affecting the academic performance and emotional well-being of students.

Self-efficacy, defined broadly as the belief in one's ability to organize and execute actions necessary to achieve specific goals (Bandura, 1997), is a key concept in adapting to new technologies. In educational settings, a high degree of technological self-efficacy allows individuals to complete assignments using technology with greater fulfillment (Yang et al., 2025). Conversely, students with lower self-efficacy may become agitated when encountering difficult tasks, choosing evasion over completion (Bandura, 2010). Self-efficacy is shaped by external elements, including feedback, rewards, communication, and motivation (Peechapol et al., 2018). Generative AI tools capable of creating content, such as text, images, or code (e.g., ChatGPT and DeepSeek) can interact with individuals via voice or text in a human-like manner, potentially enhancing communication, engagement, and learning experiences (Labadze et al., 2023). In Biology education, students' psychological states affect how confidently they face academic challenges and apply biological concepts in their daily lives. While high self-efficacy fosters adaptability, low confidence can inhibit learning quality and conceptual application. Studies have shown that AI instruction can significantly modulate psychological impacts on learners. For instance, a study by Huang et al. (2024) highlighted that learners' acceptance of AI positively influences their well-being and confidence. Similarly, Nabila and Amrullah (2025) indicated that AI instructional tools contribute significantly to student



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efficiency, improved academic performance, elevated self-efficacy, and enhanced learning engagement. Researchers like Zhang and Aslan (2021) emphasize the importance of understanding student-centered viewpoints to create AI tools that align with students' cognitive capacities. While research by Yaseen et al. (2025) indicates that AI tools support autonomous learning by providing tailored feedback, empirical data on how well these tools cultivate independent confidence remains limited. Three main approaches, learning from AI, learning about AI, and learning with AI were identified in a study looking at the integration of AI in K–12 schools, which noted that interrelated institutional barriers often impede progress, requiring customized school strategies (Wang & Cheng, 2021). Najmuddeen et al. (2024) investigated the impact of AI-based learning systems on biology education among students in Zaria, Kaduna State, utilizing a sample of 150 teachers and students. Data gathered via a Likert-scale questionnaire revealed that AI integration significantly enhances academic performance, conceptual retention, and student motivation compared to traditional methods. Statistical analysis showed mean scores consistently exceeding the evaluation threshold, with significant p-values across the hypotheses. Consequently, the study recommended that educators adopt AI tools to foster higher engagement and identify at-risk students for early interventions. Naeem et al. (2024) conducted a systematic study of 74 records to investigate the transformative impact of AI on secondary biology education, focusing on instruction, assessment, and administration. The research highlighted how AI interventions, such as personalized learning and simulators, address complex biological topics like genetics and cell biology. The study identified that AI significantly enhances learner outcomes and provides educators with efficient tools for performance assessment, offering a framework for policymakers to navigate AI integration challenges.

A study by Duy et al. (2025) explored AI integration in biology self-learning among high school students, revealing departures from the traditional Technology Acceptance Model (TAM). While students perceived AI as useful, this did not automatically translate into a strong behavioral intention to use it for advanced tasks. Instead, students primarily utilized AI for exam preparation and homework rather than complex experimental simulations, citing concerns over data accuracy, privacy, and limited virtual laboratory capabilities. The findings suggest that to move beyond basic chatbot interactions, educational institutions must prioritize specialized AI tools alongside comprehensive AI literacy programs. Benjamin et al. (2025) investigated the efficacy of the Technology-Education-Art (TEA) application in enhancing visual literacy among 85 biology students in Lagos, Nigeria, a group historically noted for struggling with the visual demands of the discipline. Quantitative analysis through Analysis of Covariance (ANCOVA) revealed no statistically significant shift in overall student attitudes toward biological sketching, but qualitative feedback indicated that students perceived the tool as highly effective. The study recommended that educational authorities prioritize technological integration as a supportive pedagogical resource rather than a threat to traditional instruction. Afolasade and Nyong (2018) investigated biology students' visual literacy skills and their effects on learning. According to their survey, 86.7% of pupils scored below 50% on the Visual Literacy Scale, indicating poor visual literacy baseline skills. The authors stressed that biology is fundamentally visual, relying on imagery to explain living systems. This emphasizes the need for creative methods to improve students' capacity to comprehend and produce biological drawings. According to the United Nations Educational, Scientific, and Cultural Organization's Beijing Consensus on Artificial Intelligence and Education (UNESCO, 2019), AI has the potential to revolutionize teaching, address major educational challenges, and hasten the achievement of the Sustainable Development Goals (SDGs). However, educational innovation faces structural



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constraints due to the historically measured pace of technology adaptation across Sub-Saharan Africa (African Union, 2023). This project investigates the interface of AI technologies and student psychological outcomes within the local educational context to address these gaps.

Statement of the Problem

Senior secondary biology is often perceived as a difficult subject due to its voluminous content and abstract concepts, leading to significant challenges among students. This often manifests as a lack of confidence, fear of failure, and avoidance of scientific inquiry, which ultimately hinders academic performance and suppresses domain self-efficacy. While many students in senior secondary schools have begun utilizing AI-assisted tools, such as intelligent tutors and generative AI to navigate these challenges, there is a dearth of empirical data on how this usage correlates with their academic self-belief. It remains unclear whether the anytime, anywhere nature of AI truly acts as a cognitive buffer that enhances self-efficacy, or if it creates a digital dependency that masks underlying conceptual difficulties. Furthermore, it is yet to be determined if the impact of these AI tools on biology self-efficacy is uniform across both male and female students. If this gap in knowledge persists, educators may continue to implement AI tools without understanding their role in student academic confidence and technological mastery. Therefore, this study seeks to investigate the relationship between the use of AI-assisted instruction and biology students' self-efficacy among senior secondary schools, while also examining the moderating role of gender.

Research Objectives

The objectives of the study were:

1. To determine the relationship between the use of AI-assisted instructional tools and the level of biology self-efficacy among senior secondary students.
2. To compare the biology self-efficacy levels of male and female students who utilize AI tools for learning.

Research Questions

The following research questions guided the study:

1. What is the relationship between students' use of AI-assisted biology instruction and their levels of biology self-efficacy?
2. Is there a significant difference in biology self-efficacy levels between male and female students who use AI-assisted tools?

Research Hypotheses

The following null hypotheses were formulated and tested at the 0.05 level of significance:

- Ho₁.** There is no significant relationship between the use of AI-assisted instructional tools and senior secondary students' biology self-efficacy.
- Ho₂.** There is no significant difference in the mean biology self-efficacy scores of male and female students who utilize AI-assisted instruction.

Research Methodology

The study employed a descriptive survey research design. The population consisted of all private senior secondary school (SSS) biology students in Gusau metropolis, Zamfara State, who utilized AI tools (such as Gemini, ChatGPT, or specialized biology learning apps) for their academic work. A sample size of 313 students was selected using a purposive sampling technique to ensure the inclusion of only those students who confirmed active use of AI tools for biology learning. The instrument, titled "Biology Students AI and Self-Efficacy Questionnaire" (BSASEQ), was developed by the researchers for data collection. The instrument was validated by measurement and evaluation experts and was pilot-tested on a cohort outside the final sample. The data from the pilot test was

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analyzed using Cronbach's alpha, establishing a reliability coefficient of 0.75. Data analysis was executed using descriptive statistics (Mean and Standard Deviation) for the research questions, while the null hypotheses were analyzed using the Pearson Product-Moment Correlation Coefficient and an independent samples t-test.

Presentation of Results

Research Question One

What is the relationship between students' use of AI-assisted biology instruction and their levels of biology self-efficacy?

Table 1: Students' Use of AI-Assisted Biology Instruction and Biology Self-Efficacy Levels

Variable	N	Mean	SD	Mean Difference
AI Usage	313	2.16	0.47	1.04
Self-Efficacy	313	3.20	0.42	

Source: Fieldwork, 2026

Table 1 displays the descriptive summary of students' use of AI-assisted biology instruction and their corresponding biology self-efficacy. AI usage obtained a mean score of 2.16 (SD=0.47), while biology self-efficacy obtained a mean score of 3.20 (SD=0.42), resulting in a mean difference of 1.04. This descriptive baseline suggests that students reported a relatively high confidence level in their biology capability while practicing moderate or infrequent utilization of AI tools.

Research Question Two

Is there a significant difference in biology self-efficacy levels between male and female students who use AI-assisted tools?

Table 2: Biology Self-Efficacy Levels Between Male and Female Students

Variable	Gender	N	Mean	SD	Mean Difference
Self-Efficacy	Male	157	3.20	0.36	0.01
	Female	156	3.19	0.47	

Source: Fieldwork, 2026

Table 2 shows the comparative self-efficacy levels between male and female students who utilize AI-assisted tools. The data indicates that male students recorded a mean self-efficacy score of 3.20 (SD=0.36), while female students recorded a mean score of 3.19 (SD=0.47). The resulting mean difference of 0.01 indicates that both groups exhibit highly similar descriptive levels of academic self-belief. However, the higher standard deviation within the female cohort indicates a slightly wider variance in self-efficacy distribution compared to their male peers.

Analysis of the Null Hypotheses

Hypothesis One: There is no significant relationship between the use of AI-assisted instructional tools and senior secondary students' biology self-efficacy.

Table 3: Pearson Product-Moment Correlation between AI Tool Usage and Biology Self-Efficacy

Variable	N	Mean	SD	df	Correlation (r)	p-value	Decision
AI Usage	313	2.16	0.47	311	.383	.888	Retained
Self-Efficacy	313	3.19	0.42				

Source: Fieldwork, 2026

Table 3 presents the correlation analysis between AI-assisted instructional tool usage and biology self-efficacy among the sampled students. The analysis revealed a Pearson correlation coefficient of 0.383 with an associated p-value of 0.888. Because the calculated p-value (0.888) is substantially greater than the designated 0.05 significance level, the null hypothesis is retained. This implies that there is no statistically significant relationship between the frequency of AI tool usage and the levels of biology self-efficacy experienced by the students.



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Hypothesis Two: There is no significant difference in the mean biology self-efficacy scores of male and female students who utilize AI-assisted instruction.

Table 4: Independent Samples t-test of Biology Self-Efficacy Scores by Gender

Gender	N	Mean	SD	t-value	p-value	Df	Decision
Male	157	3.20	0.47	0.194	.847	311	Retained
Female	156	3.19	0.36				

Source: Fieldwork, 2026

Table 4 indicates that male students reported a mean self-efficacy score of 3.20 (SD=0.47), while female students reported a mean self-efficacy score of 3.19 (SD=0.36). The inferential analysis shows that this minor variation was not statistically significant, t value=0.194, p =0.847. Consequently, the second null hypothesis is retained, demonstrating that gender does not exert a significant moderating impact on the academic self-efficacy levels of the participants.

Discussion of the Findings

According to literature on AI literacy (Chai et al., 2021), students frequently maintain fixed perceptions of their academic abilities when digital instructional tools are treated as optional or peripheral rather than fully integrated elements. This aligns with the baseline descriptive observation in Table 1, where solid self-efficacy profiles co-occurred alongside lower, non-systematic tool utilization. Concurrently, Ocaña-Fernández et al. (2019) observed that when modern digital platforms are smoothly integrated directly within structural curricula, contemporary students leverage them naturally without fundamentally altering their pre-existing confidence baselines. This indicates that core self-efficacy traits may be driven by fundamental classroom interactions rather than the digital tools themselves. Furthermore, the absence of significant gender differences in technology-mediated self-efficacy corroborates the findings of Recber et al. (2018), who noted minimal gender discrepancies within structured digital learning spaces, though it diverges from patterns observed by Vekli (2021).

The non-significant correlation between AI integration and biology self-efficacy ($r=0.383$, $p>0.05$) conceptually supports the core tenets of the Technological Pedagogical Content Knowledge (TPACK) framework (Koehler & Mishra, 2009). This structural framework implies that introducing a technical medium as a general instructional aid does not automatically elevate or alter a learner's fundamental academic self-concept toward the subject matter. These findings further corroborate the assertions of Oloyede et al. (2022) within the West African secondary school environment, which demonstrated that subject-specific student confidence is predominantly dictated by immediate environmental variables—such as historical teacher-student relationships, continuous assessment feedback, and extensive curriculum volume—rather than the specific technological channel utilized for lesson delivery. The findings fail to support the optimistic predictions of Luckin (2018), who argued that customized, AI-driven personalized feedback loops should noticeably elevate student confidence levels by providing rapid, nonjudgmental mastery support. The findings also disagree with Huang et al. (2024) who highlighted that learners' acceptance of AI positively influences their well-being and confidence and Nabila and Amrullah (2025) who indicated that AI instructional tools contribute significantly to student efficiency, improved academic performance, elevated self-efficacy, and enhanced learning engagement. The absence of a significant statistical link in this study indicates that AI tools currently act as neither an acute booster nor a primary detractor of academic self-efficacy among senior secondary biology students in the study area.

Conclusion



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The non-significant relationship between the usage of AI-assisted tools and biology self-efficacy implies that integrating AI into secondary science classrooms does not inherently alter or destabilize the pre-existing confidence baselines of learners. Furthermore, given the lack of statistically meaningful differences in self-efficacy profiles across gender groups, it is concluded that current educational AI integration strategies within the study area should prioritize universal technological empowerment and accessible infrastructure rather than gender-segregated interventions.

Recommendations

1. Because the findings revealed that AI usage does not have a statistically significant relationship with student self-efficacy, future empirical research should be conducted in the region to determine if AI-assisted instruction significantly impacts alternative student learning outcomes, such as performance, conceptual retention, interest, and intrinsic motivation.
2. Educational institutions should design and deploy comprehensive AI literacy modules focusing on the practical application, operations, and ethical boundaries of AI to ensure students interact with assistive technologies productively and confidently.

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