Artificial Intelligence and The Future of Biology Education Among Secondary Schools in Anambra State, Nigeria

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ABSTRACT

This study investigates the influence of Artificial Intelligence (AI) on the future of biology education by examining the perceptions of students and educators regarding its role in teaching and learning processes. Using a descriptive survey design, data were collected from 100 purposively selected respondents through a validated Likert-scale questionnaire and analyzed using descriptive statistics and ANOVA in SPSS. The findings reveal that respondents generally perceive AI as a positive and transformative tool in biology education. AI was highly rated for its ability to support teachers in developing high-quality instructional materials and improving students' learning outcomes. The study also found that AI significantly influences perceptions of the future of biology education, with notable differences across age groups, while gender differences were statistically insignificant. Respondents acknowledged AI's potential to enhance motivation, accessibility, virtual laboratory experiences, and independent learning. However, concerns regarding ethical implementation, overdependence on technology, and the need for adequate teacher training and infrastructure were also highlighted. The study concludes that AI will become a major driver of innovation and modernization in biology education.

Keyword: Artificial Intelligence; Biology Education; Educational Technology; Descriptive Survey; Inferential Analysis

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1. INTRODUCTION

The field of biology education is currently experiencing a transformative era driven by Artificial Intelligence (AI). AI is reshaping the educational landscape, and biology education is no exception. AI has increasingly been adopted in the education sector, offering innovative approaches that enhance teaching and learning, improve student engagement, facilitate research, and support the evaluation of educational outcomes. AI technologies are particularly beneficial in biology education, a scientific discipline that relies heavily on experimentation, observation, data analysis, and problem-solving (Ebele, 2026). Consequently, the future of biology education appears promising, as AI tools and digital learning platforms make learning more interactive, personalized, and research-oriented.

Personalized learning can be enhanced through AI by tailoring instructional materials to the specific needs of each learner. Intelligent tutoring systems, virtual laboratories, and adaptive learning platforms can identify students' strengths and weaknesses and provide appropriate learning experiences. In higher education, AI frameworks encourage the responsible and structured use of intelligent technologies, thereby fostering effective teaching and learning (Chan, 2023; Akachukwu et al., 2026). In biology education, this means that students can receive customized explanations of complex topics such as genetics, ecology, physiology, and molecular biology. AI-powered systems can also provide immediate feedback during practical and theoretical exercises, thereby improving understanding and knowledge retention.

Experiential and collaborative learning are also important areas in which AI enhances biology education. Practical activities such as laboratory work, fieldwork, and simulations are essential components of biology learning (Akachukwu et al., 2025). Through AI technologies, virtual experiments and interactive

simulations can now be conducted, enabling students to experience real-life biological processes without the limitations of physical laboratories. Duchatelet et al. (2024) emphasized that experiential learning environments play a significant role in achieving generic learning outcomes in higher education. AI-powered virtual laboratories allow biology students to manipulate variables, observe outcomes, and repeat simulations multiple times, thereby promoting deeper understanding and scientific inquiry.

Moreover, AI contributes to employability and professional skills development among students. Biology education is not solely concerned with knowledge acquisition but also with the development of technological and practical competencies required in contemporary society. Aditya et al. (2024) revealed that AI positively influences the employability skills of students across different countries. Biology students can utilize AI tools for data analysis, scientific writing, bioinformatics, and research management. Careers in biotechnology, medicine, environmental science, microbiology, and genetics will increasingly demand competence in AI applications.

In the educational sector, the widespread adoption of generative AI also creates opportunities for teachers and students to improve biology learning experiences. AI tools can generate lesson plans, quizzes, diagrams, summaries, and instructional materials that simplify complex biological concepts. Granić (2025) highlighted increased accessibility, efficiency, and learner engagement as major factors driving the adoption of generative AI in education. Biology teachers can use AI to design interactive classroom activities, while students can employ AI tools for independent learning and revision. Consequently, future biology curricula are expected to become more flexible, learner-centered, and technologically oriented.

Despite its numerous advantages, AI in biology education also raises ethical and social concerns. Academic dishonesty, excessive dependence on technology, privacy issues, and intellectual property violations remain major challenges. Nwadigwe and Ilukwe (2023) discussed the increasing concerns regarding copyright infringement and piracy in creative industries, issues that are equally relevant in educational institutions where AI-generated content is widely utilized. Therefore, educational institutions must establish clear policies and ethical guidelines to ensure the responsible use of AI in biology teaching and learning.

Furthermore, the psychological and moral implications of AI use among students should not be overlooked. Achebe and Onyemaechi (2023) noted that moral disengagement may contribute to inappropriate adolescent behavior. Although AI can serve as a valuable educational resource, students may become overly dependent on it and consequently fail to develop critical thinking and creativity. Onyemaechi et al. (2025) also highlighted the psycho-social dimensions associated with societal changes and media influence. If not properly regulated, AI technologies in education may negatively affect students' social interaction, communication skills, and emotional development.

In addition, the effective implementation of AI in biology education requires empowered teachers and adequate institutional support systems. Nwokolo et al. (2022) emphasized the importance of psychological empowerment in enhancing positive organizational behavior. Teachers who are well-prepared and motivated are more likely to successfully integrate AI into biology instruction. Therefore, teacher training, technological infrastructure, and curriculum redesign are essential for educational institutions to prepare students for future scientific and technological challenges.

The study of Artificial Intelligence and the future of biology education is highly relevant because it provides insights into how AI can improve teaching effectiveness, student engagement, personalized learning, and scientific research skills in biology. Previous studies have mainly focused on AI in general education and employability development (Aditya et al., 2024; Chan, 2023), while limited research has specifically explored AI applications in biology education. Similarly, Granić (2025) discussed generative AI in general educational contexts without focusing on biology classrooms or laboratory-based learning. Therefore, this study seeks to address this gap by examining the potential of AI technologies to transform biology teaching, practical learning experiences, and future scientific competencies within educational institutions.

2. RESEARCH METHOD

A. Methodology

This study employed a descriptive survey research design. The design was considered appropriate because it enabled the researchers to systematically collect, analyze, and describe respondents' perceptions regarding the influence of Artificial Intelligence (AI) on the future of biology education without manipulating any variables. The study was conducted in selected educational institutions within the region. The area was selected due to the increasing integration of digital technologies and emerging AI applications into the local academic curriculum, making the academic population relevant for investigating technological advancements in science education. The participants consisted of active biology students and instructors from the selected institutions. These participants possessed firsthand experience with biology teaching resources, common

learning challenges, and modern educational technologies such as the internet, computers, and mobile devices, thereby enabling them to provide meaningful responses.

A total of 100 respondents participated in the study. Purposive sampling techniques were employed to select participants based on demographic criteria such as gender and age distribution. The sample comprised 44 male and 56 female respondents representing various age groups: adolescents aged 15–20 years, young adults aged 21–30 years, and adults aged 31 years and above. The primary instrument used for data collection was a structured questionnaire titled *Influence of Artificial Intelligence on Biology Education Questionnaire*. The questionnaire consisted of two sections. Section A collected demographic information, including gender and age, while Section B contained 15 statement items measured on a standard Likert scale ranging from strongly disagree to strongly agree. These items were designed to assess respondents' perceptions regarding the use and influence of AI in biology education.

To ensure the validity of the instrument, the initial draft of the questionnaire was reviewed by two experts in Science Education and one expert in Educational Measurement and Evaluation. These experts examined the instrument for clarity, relevance, and consistency with the research objectives, and their suggestions were incorporated into the final version. A pilot study was also conducted using a small representative sample from a location different from the main study area to determine the reliability of the instrument. Cronbach's alpha coefficient was used to measure internal consistency, and the reliability coefficient obtained exceeded the acceptable threshold of 0.70, indicating that the instrument was reliable for data collection.

The questionnaire was administered directly to the respondents by the researchers. Prior to administration, the academic purpose of the study was explained, and participants were assured of the confidentiality of their responses. All 100 questionnaires distributed were successfully completed and returned, resulting in a 100% response rate. The collected data were coded and analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including mean scores, standard deviations, and variances, were used to answer the research questions and identify trends in respondents' perceptions. Hypotheses testing was conducted using one-way Analysis of Variance (ANOVA) and Tests of Between-Subjects Effects to determine the significance of AI's influence and to evaluate the effects of gender and age on respondents' perceptions at a 0.05 level of significance.

B. Hypotheses

1. There is no significant influence of Artificial Intelligence on the future of biology education as perceived by respondents.
2. There is no significant difference between male and female respondents' perceptions of the influence of Artificial Intelligence on the future of biology education.
3. There is no significant difference in respondents' perceptions of the influence of Artificial Intelligence on the future of biology education based on age.

3. RESULTS AND DISCUSSION

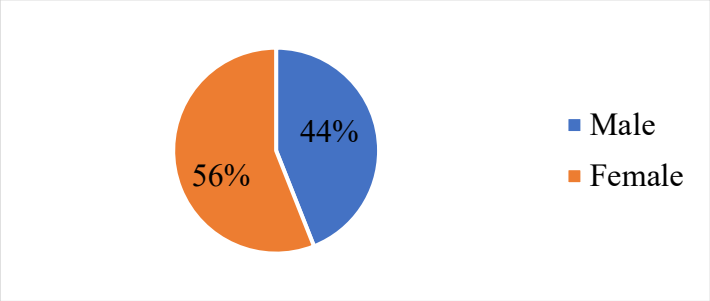

Figure 1. Distribution of Respondents by Gender

Figure 1 illustrates the gender distribution of the respondents involved in the study. Out of the total 100 participants, 44 respondents were male, representing 44.0% of the sample population, while 56 respondents were female, accounting for 56.0%. This indicates that female participants were slightly more represented than male participants in the study. The dataset shows complete accuracy and consistency, as there were no missing responses, reflected by the identical values recorded under both the percent and valid percent categories.

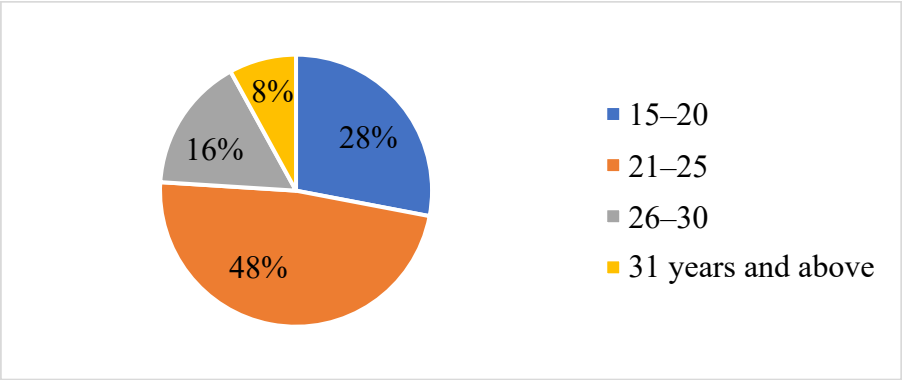

Figure 2. Distribution of Respondents by Age

Figure 2 presents the distribution of respondents according to age groups. The largest proportion of respondents belonged to the 21–25 age category, consisting of 48 participants or 48.0% of the total sample. This was followed by respondents aged 15–20 years, who accounted for 28 participants or 28.0%. Participants within the 26–30 age range constituted 16.0% of the sample with 16 respondents, while respondents aged 31 years and above represented the smallest category with only 8 participants or 8.0% of the sample. These findings indicate that the majority of respondents were relatively young individuals, reflecting a predominantly youthful demographic among the participants surveyed in the study.

Table 1. Mean and Standard Deviation Analysis on the Influence of Artificial Intelligence on the Future of Biology Education

	N	Mean	Std. Deviation	Variance
Artificial Intelligence has enhanced the teaching of concepts related to biology.	100	2.56	1.209	1.461
AI technologies enhance the interaction and engagement of biology learning.	100	2.44	1.242	1.542
The use of Artificial Intelligence improves the student's knowledge on the concepts of Biology.	100	2.64	1.097	1.202
The use of AI-driven learning tools can enhance students' learning outcomes in the field of Biology.	100	2.86	1.025	1.051
In biology education, the implementation of Artificial Intelligence is related to personalized learning.	100	2.24	1.248	1.558
AI can support biology teachers in creating high-quality teaching resources.	100	2.92	1.061	1.125
The use of AI can increase students' motivation to learn biology.	100	2.70	1.243	1.545
Virtual laboratory experiences can be fostered in biology education through Artificial Intelligence.	100	2.48	1.227	1.505
AI technologies have the potential to positively impact the future of biology teaching.	100	2.48	1.227	1.505
The use of Artificial Intelligence can enhance the accessibility of biology learning resources.	100	2.60	1.318	1.737
Students can more easily tackle complex biology problems with the aid of AI tools.	100	2.60	1.318	1.737
Biology students get stimulated to learn independently by Artificial Intelligence.	100	2.56	1.380	1.905
AI's role in biology education will alleviate learning challenges.	100	2.68	1.370	1.876
The use of AI can enhance the synergy between biology teachers and students.	100	2.68	1.370	1.876
AI is going to be a key driver of future biology teaching and learning	100	2.48	1.227	1.505
Valid N (listwise)	100			

Table 1 presents the descriptive statistical analysis of respondents' perceptions regarding the influence of Artificial Intelligence (AI) on the future of biology education. The analysis reveals generally positive perceptions toward the integration of AI in biology teaching and learning. Among all the questionnaire items, the statement *"AI can support biology teachers in creating high-quality teaching resources"* recorded the highest mean score of 2.92 with a standard deviation of 1.061, indicating strong agreement among respondents regarding the usefulness of AI in improving instructional materials. Similarly, the statement *"The use of AI-driven learning tools can enhance students' learning outcomes in the field of Biology"* obtained a high mean

score of 2.86 and a standard deviation of 1.025, suggesting that respondents believe AI technologies positively contribute to students' academic performance and understanding of biology concepts.

In contrast, the statement *"In biology education, the implementation of Artificial Intelligence is related to personalized learning"* recorded the lowest mean score of 2.24 with a standard deviation of 1.248. This result indicates comparatively lower agreement among respondents concerning the current implementation of personalized learning through AI in biology classrooms. Nevertheless, most of the remaining questionnaire items recorded moderate mean scores ranging from 2.48 to 2.70, demonstrating that respondents generally perceive AI as beneficial in improving student motivation, accessibility to learning resources, independent learning, classroom interaction, and the reduction of learning difficulties in biology education.

The standard deviation values across the items ranged from 1.025 to 1.380, suggesting moderate variability in respondents' opinions. Additionally, the variance values indicate that respondents' perceptions were reasonably distributed across the scale. Overall, the findings from Table 1 suggest that respondents hold favorable perceptions regarding the role of Artificial Intelligence in transforming and improving the future of biology education.

A. Hypothesis 1

There is no significant influence of Artificial Intelligence on the future of biology education as perceived by respondents.

Table 2. ANOVA Testing of the Significance of the Influence of Artificial Intelligence on the Future of Biology Education

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.340	3	3.447	3.302	.024
Within Groups	100.217	96	1.044		
Total	110.557	99			

Table 2 presents the results of the one-way Analysis of Variance (ANOVA) conducted to determine whether Artificial Intelligence significantly influences the future of biology education as perceived by respondents. The analysis produced an F-value of 3.302 with a significance value (p-value) of .024. Since the obtained p-value of .024 is lower than the accepted alpha level of .05, the null hypothesis is rejected.

This result indicates that Artificial Intelligence has a statistically significant influence on the future of biology education according to the perceptions of the respondents. The findings suggest that respondents believe AI technologies will play an important role in transforming biology teaching and learning processes. Furthermore, the statistically significant variation observed among the groups implies that differences in respondents' perceptions are meaningful and not due to chance. Overall, the findings reinforce the growing recognition of AI as a transformative factor in modern biology education.

B. Hypothesis 2

There is no significant difference between male and female respondents' perceptions of the influence of Artificial Intelligence on the future of biology education.

Table 3. ANOVA Testing Based on Gender Differences

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.166[a]	1	3.166	2.889	.092
Intercept	652.581	1	652.581	595.513	.000
Gender	3.166	1	3.166	2.889	.092
Error	107.391	98	1.096		
Total	783.787	100			
Corrected Total	110.557	99			

Table 3 presents the Tests of Between-Subjects Effects used to examine whether gender significantly influences respondents' perceptions regarding the impact of Artificial Intelligence on the future of biology education. The analysis shows that the gender variable recorded an F-value of 2.889 with a significance value (p-value) of .092. Since the p-value of .092 is greater than the standard alpha level of .05, the null hypothesis is accepted.

This result indicates that there is no statistically significant difference between male and female respondents in their perceptions of the influence of Artificial Intelligence on the future of biology education. Although slight differences exist in the descriptive statistics, these differences are not strong enough to be considered statistically meaningful. Therefore, both male and female respondents generally share similar views regarding the importance and future impact of AI in biology teaching and learning.

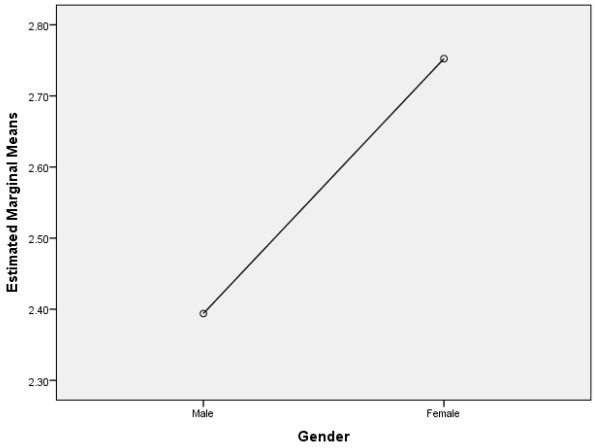

Figure 3. Estimated Marginal Means of Influence of Artificial Intelligence on the Future of Biology Education by Gender

Figure 3 illustrates the estimated marginal means of respondents' perceptions according to gender. The profile plot indicates that male respondents recorded a lower estimated marginal mean, positioned slightly below 2.40, whereas female respondents demonstrated a comparatively higher estimated marginal mean of approximately 2.75. This descriptive trend suggests that female respondents tend to hold more positive perceptions regarding the influence of Artificial Intelligence on biology education than male respondents.

However, despite the observable difference in the graphical representation, the statistical analysis previously conducted revealed that the difference was not significant at the 0.05 level. This implies that gender does not substantially affect respondents' overall perceptions of AI in biology education. The findings therefore suggest that both genders generally acknowledge the potential benefits and future contributions of AI to biology teaching and learning processes.

C. Hypothesis 3

There is no significant difference in respondents' perceptions of the influence of Artificial Intelligence on the future of biology education based on age.

Table 4. Tests of Between-Subjects Effects on Respondents' Perceptions by Age

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.340[a]	3	3.447	3.302	.024
Intercept	505.980	1	505.980	484.689	.000
Age	10.340	3	3.447	3.302	.024
Error	100.217	96	1.044		
Total	783.787	100			
Corrected Total	110.557	99			

Table 4 presents the results of the Tests of Between-Subjects Effects conducted to determine whether age significantly influences respondents' perceptions regarding the impact of Artificial Intelligence on the future of biology education. The analysis revealed an F-value of 3.302 with a significance value (p-value) of .024 for the age variable. Since the obtained p-value of .024 is lower than the accepted alpha level of .05, the null hypothesis is rejected.

This finding indicates that there is a statistically significant difference in respondents' perceptions of the influence of Artificial Intelligence on biology education based on age. In other words, respondents from different age groups hold varying perspectives regarding the role and future impact of AI in biology teaching and learning. The result suggests that age is an important factor influencing attitudes toward the adoption and integration of AI technologies in educational settings.

The statistical significance further implies that respondents' viewpoints concerning AI are shaped by generational differences, levels of exposure to technology, and varying educational experiences. Therefore, perceptions of AI in biology education are not uniform across all age groups, but instead differ significantly according to respondents' age categories.

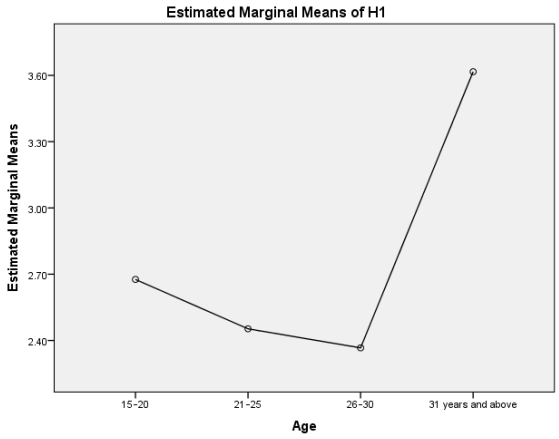

Figure 4. Estimated Marginal Means of Influence of Artificial Intelligence on the Future of Biology Education by Age

Figure 4 illustrates the estimated marginal means of respondents' perceptions according to age groups. The graphical trend shows a gradual decline in mean perception scores from the 15–20 age group to the 26–30 age category, with the lowest estimated marginal mean recorded slightly below 2.40 among respondents aged 26–30 years. However, the pattern changes significantly for respondents aged 31 years and above, where the estimated marginal mean rises sharply to approximately 3.60.

This trend suggests that older respondents tend to have more positive perceptions regarding the influence of Artificial Intelligence on the future of biology education compared to younger respondents. The findings imply that respondents in the older age category may recognize the transformative potential of AI more strongly, possibly due to broader academic or professional experiences. Conversely, younger respondents appear relatively more cautious or moderate in their perceptions of AI integration within biology education.

Overall, the figure supports the statistical findings presented in Table 5, confirming that age significantly shapes respondents' perceptions of the role of Artificial Intelligence in the future of biology teaching and learning.

D. Discussion of Findings

The findings presented in Table 1 indicate that respondents generally perceive Artificial Intelligence (AI) as a highly beneficial component in biology education. The highest mean score (M = 2.92) was recorded for the statement that AI supports biology teachers in creating high-quality teaching resources, while another high mean score (M = 2.86) reflected respondents' agreement that AI-driven learning tools enhance students' learning outcomes in biology. These findings suggest that respondents recognize AI as an effective educational tool capable of improving instructional quality and enhancing students' understanding of biological concepts. This result is consistent with the study conducted by Ana Granić (2025), which emphasized that AI applications and machine learning technologies significantly improve learner engagement, conceptual understanding, and academic achievement in scientific disciplines.

However, the item related to personalized learning recorded the lowest mean score (M = 2.24), indicating that respondents were less convinced about the current effectiveness of AI in providing personalized learning experiences in biology education. This finding contrasts with the review conducted by Duchatelet et al. (2024), which identified personalized learning as one of the fastest-growing applications of AI in higher education. The relatively lower perception observed in this study may suggest limited exposure to advanced adaptive learning systems or inadequate implementation of personalized AI technologies within the respondents' educational environments.

The inferential analysis for Hypothesis 1 revealed a statistically significant influence of AI on the future of biology education ($F = 3.302$, $p = .024$). This finding demonstrates that respondents strongly believe AI will play a transformative role in shaping future biology teaching and learning processes. The result supports the findings of Aditya et al. (2024), who reported that conversational and generative AI systems are capable of transforming how students learn, interact with, and solve complex scientific problems. Therefore, the present study reinforces the growing perspective that AI technologies will become increasingly important in modern science education.

Regarding gender differences examined under Hypothesis 2, the Tests of Between-Subjects Effects showed no statistically significant difference between male and female respondents' perceptions ($F = 2.889$, $p = .092$). This suggests that both genders generally share similar attitudes toward the influence of AI in biology education. The finding aligns with the work of Cecilia K. Y. Chan (2023), who found that perceptions of technological effectiveness tend to overlap across genders when institutional access and technological infrastructure are equally available. Although Figure 3 showed that female respondents had a slightly higher estimated marginal mean compared to male respondents, the difference was not statistically significant. This indicates that gender does not substantially determine perceptions of AI integration in biology education.

Furthermore, Hypothesis 3 revealed that age significantly influenced respondents' perceptions of AI in biology education ($F = 3.302$, $p = .024$). Figure 4 demonstrated that respondents aged 31 years and above recorded the highest estimated marginal mean (approximately 3.60), indicating stronger positive perceptions toward AI applications in biology education. This finding suggests that older respondents may better appreciate the transformative potential of AI due to broader academic or professional experiences. Conversely, younger respondents displayed relatively lower perception scores despite being more exposed to digital technologies in their daily lives. This finding contrasts with existing literature on educational technology adoption, which often reports that younger individuals tend to exhibit greater trust and familiarity with generative AI systems. Overall, the results indicate that age plays a significant role in shaping perceptions regarding the future influence of AI on biology teaching and learning.

E. Implications of the Findings

The findings of this study suggest that Artificial Intelligence (AI) is becoming increasingly important as a technological tool for supporting biology education. Most respondents agreed that AI enhances teaching effectiveness, student engagement, learning motivation, and academic outcomes. These findings imply that AI has the potential to simplify complex biological concepts, improve classroom interaction, and encourage self-directed learning among students. Furthermore, respondents strongly acknowledged AI's contribution to the development of high-quality teaching resources, indicating that AI can significantly improve the overall quality of teaching and learning processes in biology education. This finding is consistent with the work of Egwuaba et al. (2025), who emphasized that innovation plays a vital role in promoting sustainable development and improving social systems such as education. Similarly, Agofure et al. (2019) noted that knowledge-driven approaches positively influence learning outcomes and learners' attitudes toward educational processes.

The findings also imply that AI can promote more practical, realistic, and interactive learning experiences through the use of virtual laboratories and simulation-based learning environments. Such technologies provide students with opportunities to engage in hands-on scientific activities without the limitations associated with physical laboratory settings. Onwuka et al. (2022) emphasized that supportive systems are essential for improving adaptability and performance, while Ilukwe and Ume (2026) highlighted the importance of interactive learning approaches in ensuring meaningful educational experiences. In addition, Chukwu et al. (2018) stressed the need for strong institutional support to ensure successful innovation and educational development.

Despite these positive implications, the study also highlights the necessity of providing adequate teacher training, technological infrastructure, and ethical guidelines for the effective integration of AI into biology education. Educational institutions and policymakers must ensure that AI technologies are implemented responsibly and sustainably. Achebe and Onyemaechi (2023) warned that poorly regulated technology usage could negatively affect human behavior and learning habits. Similarly, Madubuko et al. (2025) argued that modern technological innovations should be carefully managed to promote positive social transformation and educational advancement. Therefore, while AI presents significant opportunities for improving biology education, its successful implementation requires balanced regulation, institutional preparedness, and ethical oversight to maximize benefits and minimize potential risks.

4. CONCLUSION

Artificial Intelligence (AI) has become a transformative force in modern education, particularly in the field of biology education, where it has the potential to significantly shape future teaching and learning practices. The findings of this study reveal that AI is perceived as a valuable tool for improving teaching effectiveness, enhancing student engagement, promoting independent learning, and strengthening students' understanding of biological concepts. Through the use of virtual laboratories, adaptive learning platforms, and intelligent teaching aids, AI can create more interactive, practical, and student-centered learning experiences in biology education.

The study further demonstrates that AI can strengthen collaboration and interaction between teachers and students while increasing access to high-quality educational resources and scientific learning experiences. These innovations can help make biology learning more engaging, flexible, and accessible for learners. However, despite these advantages, the study also emphasizes the importance of proper implementation, adequate technological infrastructure, teacher training, and ethical regulation in integrating AI into biology education.

If not properly managed, excessive reliance on AI may negatively affect students' critical thinking abilities, creativity, and responsible learning behaviors. Therefore, educational institutions, policymakers, and other stakeholders must ensure that AI technologies are implemented responsibly and monitored effectively. By promoting ethical and innovative use of AI, educational systems can maximize its benefits while minimizing potential risks, thereby ensuring that AI contributes positively to the future development of biology education.

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