

Artificial Intelligence (AI)-Driven Instruction Effects on Biology Students' Achievement and Ethical Practices in Lagos Island Public and Private Secondary Schools

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Abstract

*This study investigated the effects of Artificial Intelligence (AI)-driven instruction on students' academic achievement and ethical classroom practices in Biology among public and private secondary schools in Lagos Island, Lagos State. The study was motivated by concerns over students' persistent difficulties in Biology and the increasing need to promote ethical behaviour in technology-supported learning environments. A quasi-experimental pre-test, post-test, nonequivalent control group design was adopted. The population comprised Senior Secondary School II (SS II) Biology students in public and private secondary schools in Lagos Island, while a sample of 120 students was selected through a multistage sampling procedure from four selected schools. Two instruments, namely the Biology Achievement Test (BAT) and the Ethical Classroom Practices Questionnaire (ECPQ), were used for data collection. The instruments were validated by experts, while reliability coefficients of 0.82 and 0.79 were obtained for the BAT and ECPQ respectively. Data were analysed using mean, standard deviation, and independent samples *t*-test at the 0.05 level of significance. The findings revealed that students exposed to AI-driven instruction achieved significantly higher academic performance than those taught using the conventional teaching method. AI-driven instruction also had a significant positive influence on students' ethical classroom practices. However, no significant differences were found between public and private school students or between male and female students exposed to AI-driven instruction. The study concluded that AI-driven instruction is an effective pedagogical approach for improving students' academic achievement and promoting ethical classroom behaviour in Biology. It was recommended that schools, teachers, and educational policymakers should encourage the integration of AI-supported instructional technologies into Biology education.*

Keywords: Artificial Intelligence, Biology Education, Academic Achievement, Ethical Classroom Practices, Secondary School Students.

Introduction

The rapid advancement of digital technologies has transformed education and created new opportunities for improving teaching and learning. Among these technologies, Artificial Intelligence (AI) has emerged as a powerful educational tool capable of supporting personalized

learning, enhancing student engagement, and improving academic outcomes. Educational institutions worldwide are increasingly integrating AI-driven technologies into instructional processes to promote learner-centred education and improve learning experiences.

The importance of science education in national development is emphasized in the Federal Republic of Nigeria's National Policy on Education (FRN, 2013), which advocates scientific literacy, technological advancement, and the integration of technology into teaching and learning. In education, AI encompasses technologies such as intelligent tutoring systems, adaptive learning platforms, educational chatbots, virtual laboratories, and automated assessment tools. These technologies provide individualized learning experiences by adapting instructional content to learners' needs. UNESCO (2021) noted that AI has the potential to improve access to quality education, promote educational equity, and enhance learning outcomes when implemented responsibly. Similarly, Holmes et al. (2019) observed that AI technologies assist teachers in monitoring students' progress and providing targeted instructional support.

Biology is a core science subject that provides foundational knowledge for careers in medicine, agriculture, biotechnology, environmental science, and other health-related fields. It also develops scientific literacy, critical thinking, and problem-solving skills. Despite its importance, students' achievement in Biology has remained a concern in Nigeria, as many learners continue to experience difficulties in understanding abstract concepts and applying scientific knowledge effectively.

Poor achievement in Biology has been attributed to factors such as inadequate instructional materials, ineffective teaching methods, overcrowded classrooms, insufficient laboratory facilities, and limited opportunities for practical learning. Traditional lecture-based methods often encourage rote memorization rather than active participation and conceptual understanding. Consequently, students frequently encounter challenges in learning complex biological concepts.

Artificial Intelligence-driven instructional approaches offer opportunities to address these challenges through adaptive learning systems, virtual laboratories, intelligent tutoring applications, and digital simulations. These technologies enable students to visualize biological

processes, conduct virtual experiments, receive immediate feedback, and learn at their own pace. Research has shown that technology-supported learning environments can improve students' engagement, conceptual understanding, retention, and academic achievement.

Beyond academic achievement, the increasing use of AI in education has generated concerns regarding ethical classroom practices, including responsible technology use, academic integrity, digital citizenship, and accountability. As learners interact more frequently with digital technologies, schools are expected to promote ethical behaviours that support responsible participation in technology-mediated learning environments. UNESCO (2021) emphasised that the effective implementation of AI in education requires the promotion of ethical standards that safeguard learners and encourage responsible digital engagement.

Although the adoption of AI-driven instructional approaches in Nigeria remains relatively limited, increasing investments in educational technology and digital learning initiatives have created opportunities for integration into classroom instruction. However, empirical studies examining the combined influence of AI-driven instruction on students' academic achievement and ethical classroom practices in Biology, particularly among public and private secondary schools in Lagos State, remain limited. This gap necessitated the present study, which investigated the influence of Artificial Intelligence-driven instruction on students' academic achievement and ethical classroom practices in Biology among public and private secondary schools in Lagos Island, Lagos State.

The increasing integration of digital technologies into education has created opportunities for improving teaching and learning outcomes. Among these innovations, Artificial Intelligence (AI)-driven instructional approaches have been identified as promising tools for enhancing students' engagement, personalized learning, and academic achievement. Despite these potentials, Biology remains one of the science subjects in which many secondary school students experience learning difficulties, resulting in unsatisfactory academic performance and limited conceptual understanding of complex biological concepts.

In addition to concerns about academic achievement, the growing use of digital learning technologies has raised important issues relating to ethical classroom practices, including responsible technology use, academic honesty, and digital citizenship. While previous studies have examined the influence of educational technologies on students' academic performance, limited attention has been given to the combined effect of Artificial Intelligence–driven instruction on both academic achievement and ethical classroom practices, particularly within the context of secondary school Biology education in Nigeria.

Furthermore, there is a paucity of empirical studies comparing the effectiveness of AI-driven instruction among students in public and private secondary schools in Lagos State. Consequently, it remains unclear whether AI-supported instructional approaches can significantly improve students' academic achievement and ethical classroom practices across different school settings. It is this knowledge gap that necessitated the present study.

Artificial Intelligence in education refers to the application of machine-based systems that can perform tasks requiring human intelligence, such as adaptive learning, automated assessment, and personalised instruction. According to Holmes *et al.* (2019), AI in education enhances teaching efficiency by tailoring content to individual learners' needs.

AI-driven instruction in Biology involves the use of simulations, virtual laboratories, and intelligent tutoring systems to facilitate understanding of complex biological processes. This aligns with constructivist learning theory, which emphasises active learner engagement and knowledge construction.

Academic achievement refers to the measurable performance outcomes of students in educational settings, often assessed through tests and examinations. Studies have shown that technology enhanced learning environments significantly improve students' achievement levels (Luckin *et al.*, 2020).

Ethical classroom practices involve students' adherence to acceptable behavioural standards such as academic honesty, responsible use of digital tools, and respect for others in a learning

environment. UNESCO (2021) emphasised that digital learning environments must promote ethical awareness and responsible technology use.

This study was anchored on Constructivist Learning Theory and Social Learning Theory.

Constructivist Learning Theory, developed by Piaget (1972), posits that learners actively construct knowledge through interaction with their environment rather than passively receiving information. The theory is relevant to AI-driven instruction because AI technologies provide personalised learning experiences, adaptive feedback, simulations, and virtual experimentation that encourage active engagement and knowledge construction. In Biology education, these features support the understanding of abstract concepts and promote meaningful learning.

The study was further supported by Social Learning Theory developed by Bandura (1977), which emphasises learning through observation, interaction, modelling, and reinforcement. The theory is particularly relevant to ethical classroom practices because AI-supported learning environments provide opportunities for collaboration, feedback, monitoring, and responsible technology use. Through these interactions, students develop behaviours associated with academic honesty, digital citizenship, and ethical classroom conduct.

Empirical studies have consistently reported positive relationships between technology-enhanced instruction and students' learning outcomes. Adebayo and Oladele (2021), Okoli and Egbunonu (2020), Ogunode (2022), Adeyemi and Salami (2023), and Eze and Nwafor (2024) revealed that technology-supported instructional approaches improved students' academic achievement, engagement, retention, and conceptual understanding. These studies also emphasised the importance of adequate technological infrastructure and teacher competence in maximising educational outcomes.

Similarly, Holmes et al. (2019), Zawacki-Richter et al. (2019), Luckin et al. (2020), Chen et al. (2020), and UNESCO (2021) reported that Artificial Intelligence-driven instructional systems promote personalised learning, adaptive feedback, learner engagement, and improved academic performance. The literature further highlighted the importance of ethical considerations such as

responsible technology use, digital citizenship, and academic integrity in AI-supported learning environments.

The reviewed literature indicates that technology-enhanced and AI-driven instructional approaches have positive effects on students' academic achievement and learning experiences.

However, most studies focused on general ICT integration rather than Artificial Intelligence–driven instruction specifically.

Furthermore, the majority of existing studies concentrated on academic achievement, with limited attention given to ethical classroom practices. There is also a scarcity of comparative studies examining the effect of AI-driven instruction among public and private secondary school students within the context of Biology education in Lagos State. Therefore, this study sought to address these gaps by investigating the effects of Artificial Intelligence–driven instruction on students' academic achievement and ethical classroom practices in Biology among public and private secondary schools in Lagos Island, Lagos State.

Research Questions.

The following research questions guided the study:

- i. What is the difference in the academic achievement of students taught Biology using AI-driven instruction and those taught using the conventional teaching method?
- ii. What is the effect of AI-driven instruction on students' ethical classroom practices in Biology?
- iii. Is there a difference in academic achievement between students in public and private secondary schools exposed to AI-driven instruction?
- iv. Is there a difference in academic achievement between male and female students exposed to AI-driven instruction?

Research Hypotheses.

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

H₀₁: There is no significant difference in the academic achievement of students taught Biology using AI– driven instruction and those taught using the conventional teaching method.

H₀₂: Artificial Intelligence (AI)–driven instruction has no significant effect on students’ ethical classroom practices in Biology.

H₀₃: There is no significant difference in the academic achievement of public and private secondary school students exposed to AI–driven instruction.

H₀₄: There is no significant difference in the academic achievement of male and female students exposed to AI–driven instruction.

Methodology

The study adopted a quasi-experimental pre-test, post-test, non-equivalent control group design. The design was appropriate for examining the effect of Artificial Intelligence (AI)–driven instruction on students’ academic achievement and ethical classroom practices in Biology. The population comprised all Senior Secondary School II (SS II) students offering Biology in public and private secondary schools in Lagos Island, Lagos State during the 2025/2026 academic session. A sample of 120 students was selected through a multistage sampling procedure. Four secondary schools were purposively selected based on the availability of SS II Biology students, access to basic digital learning facilities, and willingness to participate in the study. Thirty students were selected from each school through stratified random sampling. Two instruments were used for data collection: the Biology Achievement Test (BAT) and the Ethical Classroom Practices Questionnaire (ECPQ). The BAT consisted of 30 multiple-choice items developed from the SS II Biology curriculum and was used to assess students’ academic achievement. The ECPQ contained 20 items on a four-point Likert scale and measured dimensions such as academic honesty, responsible technology use, classroom participation, collaboration, and digital citizenship. The instruments were validated by two Science Education experts and one Measurement and

Evaluation expert to ensure clarity, relevance, and alignment with the study objectives. Reliability was established using KR-20 for the BAT and Cronbach's Alpha for the ECPQ, yielding coefficients of 0.82 and 0.79, respectively, indicating satisfactory internal consistency. Permission was obtained from the participating schools before the commencement of the study. The BAT and ECPQ were administered as pre-tests, after which the experimental group received six weeks of AI-driven instruction involving adaptive learning applications, intelligent tutoring systems, virtual Biology simulations, and AI-supported feedback. The control group was taught the same concepts using the conventional teaching method. At the end of the treatment period, both instruments were re-administered as post-tests. Data were analysed using mean and standard deviation to answer the research questions, while an independent samples t-test was used to test the hypotheses at the 0.05 level of significance. Cohen's *d* was computed to determine the magnitude of observed differences. Ethical principles guiding educational research were strictly observed throughout the study. Approval to conduct the study was obtained from the management of the participating schools. Participation was voluntary, and students were informed of the purpose of the study. Confidentiality and anonymity of participants were maintained, and all information collected was used solely for academic and research purposes.

Results and Discussion of Findings

Analysis of Research Questions

Research Question 1: What is the difference in the academic achievement of students taught Biology using AI-driven instruction and those taught using the conventional lecture method?

Table 1: Mean and Standard Deviation of Academic Achievement Scores of Students Exposed to AI-Driven Instruction and Conventional Teaching Method.

| Group | N | Mean | SD | Mean Difference |
|-----------------------|----|-------|------|-----------------|
| AI-Driven Instruction | 60 | 72.84 | 8.21 | |
| Conventional Method | 60 | 58.37 | 9.14 | 14.47 |

Table 1 shows that students exposed to AI-driven instruction obtained a mean achievement score of 72.84 with a standard deviation of 8.21, while students taught through the conventional method recorded a mean score of 58.37 with a standard deviation of 9.14. The mean difference of 14.47 indicates that students taught using AI-driven instruction performed better academically than those taught using the conventional method.

Research Question 2: What is the effect of AI-driven instruction on students' ethical classroom practices?

Table 2: Mean and Standard Deviation of Ethical Classroom Practices Scores.

| Group | N | Mean | SD | Mean Difference |
|-----------------------|----------|-------------|-----------|------------------------|
| AI-Driven Instruction | 60 | 78.25 | 7.46 | |
| Conventional Method | 60 | 67.10 | 8.32 | 11.15 |

Table 2 indicates that students exposed to AI-driven instruction obtained a mean ethical classroom practice score of 78.25, while students taught through the conventional method obtained a mean score of 67.10. The observed mean difference of 11.15 suggests that AI-driven instruction positively affects ethical classroom practices among Biology students.

Research Question 3: Is there a difference in academic achievement between public and private school students exposed to AI-driven instruction?

Table 3: Mean and Standard Deviation of Academic Achievement Scores of Public and Private School Students in the AI Group.

| School Type | N | Mean | SD | Mean Difference |
|--------------------|----------|-------------|-----------|------------------------|
| Public Schools | 30 | 70.22 | 8.44 | |
| Private Schools | 30 | 75.46 | 7.83 | 5.24 |

Table 3 reveals that private school students recorded a slightly higher mean achievement score 75.46 than public school students 70.22. However, the difference is relatively small and requires hypothesis testing to determine whether it is statistically significant.

Research Question 4: Is there a difference in academic achievement between male and female students exposed to AI-driven instruction?

Table 4: Mean and Standard Deviation of Academic Achievement Scores of Male and Female Students Exposed to AI-Driven Instruction.

| Gender | N | Mean | SD | Mean Difference |
|---------------|----------|-------------|-----------|------------------------|
| Male | 31 | 73.15 | 8.10 | |
| Female | 29 | 72.51 | 8.36 | 0.64 |

Table 4 shows that male students recorded a mean score of 73.15, while female students recorded a mean score of 72.51. The mean difference of 0.64 suggests minimal variation in achievement between male and female students exposed to AI-driven instruction.

Hypothesis Testing

H_{01} : There is no significant difference in the academic achievement of students taught Biology using

AI-driven instruction and those taught using the conventional teaching method.

Table 5: Independent Samples t-test Comparing Academic Achievement Scores

| Variable | N | Mean | SD | T | Df | p-value | Decision |
|--------------------|----------|-------------|-----------|----------|-----------|----------------|-----------------|
| AI Group | 60 | 72.84 | 8.21 | 9.14 | 118 | .000 | Reject H_0 |
| Conventional Group | 60 | 58.37 | 9.14 | | | | |

Since the calculated p-value (0.000) is less than the 0.05 level of significance, the null hypothesis was rejected. Therefore, there is a significant difference in the academic achievement of students taught Biology using AI-driven instruction and those taught using the conventional method.

H₀₂: AI-driven instruction has no significant effect on students' ethical classroom practices.

Table 6: Independent Samples t-test Comparing Ethical Classroom Practices Scores.

| Variable | N | Mean | SD | T | Df | p-value | Decision |
|--------------------|----|-------|------|------|-----|---------|-----------------------|
| AI Group | 60 | 78.25 | 7.46 | 7.81 | 118 | .000 | Reject H ₀ |
| Conventional Group | 60 | 67.10 | 8.32 | | | | |

Since the p-value (0.000) is less than 0.05, the null hypothesis was rejected. Therefore, AI-driven instruction significantly affected students' ethical classroom practices.

H₀₃: There is no significant difference in the academic achievement of public and private school students exposed to AI-driven instruction.

Table 7: Independent Samples t-test Comparing Public and Private School Students.

| Variable | N | Mean | SD | T | Df | p-value | Decision |
|-----------------|----|-------|------|------|----|---------|-----------------------|
| Public Schools | 30 | 70.22 | 8.44 | 1.98 | 58 | .052 | Accept H ₀ |
| Private Schools | 30 | 75.46 | 7.83 | | | | |

Since the p-value (0.052) is greater than the 0.05 level of significance, the null hypothesis was accepted.

Therefore, there is no statistically significant difference in academic achievement between public and private school students exposed to AI-driven instruction.

H₀₄: There is no significant difference in the academic achievement of male and female students exposed to AI-driven instruction.

Table 8: Independent Samples t-test Comparing Male and Female Students.

| Variable | N | Mean | SD | T | Df | p-value | Decision |
|----------|----|-------|------|------|----|---------|-----------------------|
| Male | 31 | 73.15 | 8.10 | 0.31 | 58 | .758 | Accept H ₀ |
| Female | 29 | 72.51 | 8.36 | | | | |

Since the p-value (0.758) is greater than 0.05, the null hypothesis was accepted. Therefore, there is no significant difference in academic achievement between male and female students exposed to AI-driven instruction.

Discussion of Findings

The study revealed that students exposed to Artificial Intelligence (AI)-driven instruction achieved significantly higher scores in Biology than those taught using the conventional teaching method. This finding supports Constructivist Learning Theory, which emphasizes active learner engagement in knowledge construction (Piaget, 1972). The result agrees with Holmes et al. (2019), Luckin et al. (2020), Chen et al. (2020), and studies by Adebayo and Oladele (2021) and Adeyemi and Salami (2023), which reported that technology-enhanced learning improves students' academic achievement through personalized instruction, adaptive feedback, and increased engagement.

The study further found that AI-driven instruction significantly improved students' ethical classroom practices. This finding supports Social Learning Theory (Bandura, 1977), which posits that behaviour develops through interaction, observation, and reinforcement. The result aligns with UNESCO (2021), which emphasised that AI-supported learning environments can promote responsible technology use, academic integrity, and digital citizenship through structured learning experiences and continuous feedback.

The findings also revealed no significant difference in the academic achievement of public and private school students exposed to AI-driven instruction. This suggests that AI-supported learning can provide comparable learning opportunities across school types when access to instructional resources is similar. The result supports Holmes et al. (2019), who argued that AI technologies have the potential to reduce learning inequalities through personalised learning pathways.

Similarly, no significant difference was found between male and female students exposed to AI driven instruction. This indicates that AI-supported learning environments provide equitable opportunities for academic success irrespective of gender. The finding reinforces the view that

effective instructional strategies are more influential in determining learning outcomes than gender differences.

Overall, the findings demonstrate that Artificial Intelligence–driven instruction can enhance academic achievement and ethical classroom practices while promoting equity across school ownership and gender categories.

The findings highlight the potential of Artificial Intelligence as an innovative instructional tool for improving Biology education. Teachers should be encouraged to integrate AI-supported applications such as, virtual simulations, and adaptive learning platforms into classroom instruction to enhance students’ understanding of complex concepts. The positive effect of AI on ethical classroom practices further suggests the need to incorporate digital citizenship, responsible technology use, and academic integrity into technology-enhanced learning programmes. Additionally, policymakers should provide adequate digital infrastructure, internet access, and teacher training to ensure equitable access to AI-supported learning opportunities in both public and private schools in Lagos State.

Conclusion

The study concluded that Artificial Intelligence–driven instruction significantly improves students’ academic achievement and ethical classroom practices in Biology. The findings also indicate that the benefits of AI-supported learning are largely independent of school type and gender. Therefore, AI-driven instruction represents a viable strategy for enhancing learning outcomes and promoting responsible classroom behaviour among secondary school students.

Recommendations

Based on the findings, the study recommends that:

1. Biology teachers should integrate AI-supported instructional tools like virtual simulations, virtual laboratories, intelligent tutoring systems and adaptive learning platforms into classroom teaching to enhance students’ learning experiences and achievement.

2. Government and school administrators should provide adequate technological infrastructure and continuous teacher training to support effective AI integration in schools.
3. Educational authorities should develop policies and ethical guidelines that promote responsible use of Artificial Intelligence in teaching and learning.
4. Public and private schools should collaborate in sharing technological resources and best practices for AI-supported instruction.

Limitations and Suggestions for Further Research

The study was limited to SS II Biology students in selected secondary schools in Lagos Island and was conducted over a six-week intervention period. Future studies should examine the long-term effects of AI-driven instruction, extend investigations to other science subjects, and explore issues relating to teachers' readiness, data privacy, academic integrity, and ethical concerns associated with Artificial Intelligence in education.

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