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EFFECT OF ARTIFICIAL INTELLIGENCE ON THE ACADEMIC PERFORMANCE OF COMPUTER SCIENCE STUDENTS IN SENIOR SECONDARY SCHOOLS IN ZARIA LOCAL GOVERNMENT AREA, KADUNA STATE

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ABSTRACT

Conventional computer science pedagogy in sub-Saharan secondary education frequently struggles with high student-to-teacher ratios and limited individualized instructional support. This study examined the effects of Artificial Intelligence (AI)-assisted instruction on senior secondary school students' academic performance, conceptual retention, and learning engagement in Computer Science. A non-equivalent control group quasi-experimental design was adopted, utilizing a sample of 98 Senior Secondary II (SS II) students (Experimental Group n = 50; Control Group n = 48) across two purposively selected schools in Zaria, Kaduna State, Nigeria. Data were collected using a validated 30-item Data Processing Achievement Test (DPAT) administered as pre- and post-tests. Independent sample t-tests demonstrated that students exposed to AI-driven adaptive instructional tools achieved significantly higher post-test mean scores in overall performance ($t(98) = 6.02$, $p < 0.05$), conceptual retention ($t(98) = 5.12$, $p < 0.05$), and assessment outcomes ($t(98) = 5.44$, $p < 0.05$) compared to the control group taught via traditional lecture methods. Furthermore, self-reported engagement indicators revealed marked improvements in the intervention group. The findings confirm that integrating conversational AI chatbots and dynamic data visualizations into STEM curricula significantly enhances cognitive outcomes and knowledge retention. Educational administrators should systematically incorporate adaptive AI platforms into secondary computer science instruction.

Keywords: Artificial Intelligence in Education, Computer Science Pedagogy, Secondary Education, Quasi-Experimental Design, Academic Achievement, Conceptual Retention.

Introduction

Science represents a systematic framework for acquiring, organizing, and empirical testing of domain knowledge. Within modern educational paradigms, Computer Science serves as a foundational discipline for driving technological literacy, computational thinking, and problem-solving capacities necessary for national development (Ramírez-Montoya et al., 2024). In Nigeria, secondary computer science education—specifically within the Data Processing curriculum—is structured to foster digital competencies and innovation in an increasingly automated workforce (Federal Ministry of Education [FME], 2023). However, traditional pedagogical models in sub-Saharan Africa remain predominantly teacher-centric, relying heavily on rote memorization,

didactic lectures, and static textbook illustrations (Tamim et al., 2020). These instructional constraints are frequently exacerbated by high student-to-teacher ratios, inadequate lab infrastructure, and limited capacity for individualized instruction, resulting in superficial conceptual understanding and poor retention (Tamim et al., 2020).

Artificial Intelligence (AI) encompassing machine learning algorithms, natural language processing, and adaptive instructional systems presents a viable paradigm shift (Russell & Norvig, 2016). Grounded in Cognitive Load Theory (Sweller, 1988), AI tools optimize cognitive architecture by presenting complex concepts via dynamic visual representations and interactive feedback, thereby reducing extraneous cognitive load and promoting germane processing. Intelligent Tutoring Systems (ITS) and conversational AI platforms facilitate personalized learning pathways tailored to individual cognitive paces (Chen et al., 2020; Holmes et al., 2019; Zawacki-Richter et al., 2023).

Despite growing global literature on AI in education, empirical evidence evaluating the integration of conversational AI tools within secondary school science classrooms in developing contexts remains sparse. Most studies originate from higher education or well-resourced Western environments. To address this contextual gap, this study empirically evaluates the effect of AI-assisted instructional tools on academic achievement, conceptual retention, and student engagement in Computer Science among senior secondary school students in Zaria, Kaduna State, Nigeria.

Statement of the Problem

Globally, educational paradigms are shifting rapidly due to advancements in Artificial Intelligence (AI), which offer unprecedented opportunities to personalize learning, boost classroom engagement, and elevate academic performance. AI-driven technologies including intelligent tutoring systems, adaptive learning platforms, virtual laboratories, and automated assessment tools have proven effective in demystifying complex technical concepts and fostering deeper conceptual mastery in science disciplines like computer science. However, despite international momentum toward AI-assisted pedagogy, the adoption, integration, and practical efficacy of these tools within secondary schools in Nigeria remain constrained, unevenly distributed, and empirically under-researched.

Objectives of the Study

The primary objective of this study is to evaluate the effect of AI on the academic performance of Computer Science students in Senior Secondary Schools in Zaria Local Government Area, Kaduna State. The specific objectives include:

1. To evaluate the effect of AI-based learning systems on students' understanding and retention of Computer Science concepts.
2. To assess the effectiveness of AI-based learning systems in improving students' academic performance in Computer Science.

3. To analyze the effect of AI-based learning systems on student engagement and motivation in learning Computer Science.
4. To compare the performance outcomes of students using AI-based learning systems with those using traditional learning methods in Computer Science.

Research Questions

To achieve the objectives outlined, the study will address the following research questions:

1. What is the effect of AI-based learning systems on students' understanding and retention of Computer Science concepts?
2. What is the effect of AI-based learning systems on students' academic performance in Computer Science?
3. In what ways do AI-based learning systems enhance students' engagement and motivation in Computer Science classes?
4. How do students who use AI-based learning systems compare to those using traditional methods in terms of Computer Science performance outcomes?

Research Hypotheses

The study will test the following hypotheses:

Ho_1: There is no significant difference in the understanding and retention of Computer Science concepts between students who engage with AI-based learning systems and those who do not.

Ho_2: There is no significant difference in academic performance in Computer Science between students exposed to AI-based learning systems and those who are not.

Ho_3: There is no significant difference in engagement and motivation between students using AI-based learning systems and those taught without such systems.

Ho_4: There is no significant difference in assessment scores in computer science between students taught with AI-based learning systems and those taught using traditional instructional methods.

Methodology

This study adopted a non-equivalent control group quasi-experimental design involving pre-tests and post-tests. This design was deemed appropriate because it allowed the researcher to utilize intact, pre-existing secondary school classes, thereby preserving normal classroom organization and avoiding administrative disruption.

The target population comprised Senior Secondary School II (SS II) students enrolled in private secondary schools within the study area. A multi-stage sampling procedure was employed. First, two private secondary schools were selected using purposive sampling to ensure institutional comparability. Second, one intact SS II class was randomly drawn from each sampled school using simple random sampling. One intact class was assigned as the Experimental Group (EG), while the other served as the Control Group (CG).

The primary instrument for data collection was the Data Processing Achievement Test (DPAT), developed by the researcher to measure students' academic performance in data processing. The DPAT comprised 30 standardized multiple-choice items adapted from the West African Examinations Council (WAEC) past examination papers (2019–2023). Each correct item attracted 2 marks, giving a maximum attainable score of 60 marks.

To establish content and face validity, the DPAT was subjected to expert appraisal. In alignment with established methodological literature (Gay, 1976; Kerlinger, 1986; Ofo, 2004), expert judgment serves as the primary standard for verifying the alignment between test items and curriculum objectives. The instrument was reviewed by experts in Computer Science Education, who evaluated the clarity, relevance, and coverage of the test items in relation to the SS II Data Processing syllabus. Modifications were made based on their recommendations before final administration.

Reliability reflects the degree of temporal consistency and stability of a measuring instrument (Nwankwo, 2018). To evaluate the internal consistency and reliability of the DPAT, a pilot study was conducted using an intact SS II class in a non-sampled school possessing similar characteristics to the study population.

The instructional intervention spanned a period of three weeks during regular school hours, comprising two 40-minute sessions per week (a total of 6 contact sessions per group, yielding 12 total contact periods). Prior to the intervention, the DPAT was administered as a pre-test to both the experimental and control groups to establish baseline academic equivalence and measure entry-level knowledge. The Experimental Group was taught Data Processing concepts using Artificial Intelligence (AI)-assisted instruction, integrating interactive AI chatbots for personalized feedback and data visualization tools. Conversely, the Control Group received instruction via traditional lecture methods, utilizing chalkboard explanations, printed diagrams, and standard textbooks. At the conclusion of the three-week instructional period, the post-test (a re-ordered version of the DPAT) was administered to both groups to measure learning gains and assess the relative efficacy of the AI-integrated approach compared to conventional teaching.

Presentation of Results

Research Question One: What is the effect of AI-based learning systems on students' understanding and retention of Computer Science concepts?

Table 1: Mean and Standard Deviation for Understanding and Retention

Group	N	Mean	S.D	Mean Difference
Experimental (AI-based)	50	74.20	10.80	11.10
Control (Non-AI)	48	63.10	11.25	
Total	**98**			

The results in Table 1 reveal that students in the experimental group recorded a higher mean score **(**74.20**)** than those in the control group (63.10). The mean difference of 11.10 indicates that

students exposed to AI-based learning systems demonstrated better understanding and retention of Computer Science concepts. This suggests that AI tools enhance content clarification, reinforcement, and learners' long-term memory.

Research Question Two: What is the effect of AI-based learning systems on students' academic performance in Computer Science?

Table 2: Mean and Standard Deviation for Academic Performance

Group	N	Mean	S.D	Mean Difference
Experimental (AI-based)	50	76.80	9.95	13.40
Control (Non-AI)	48	63.40	10.15	
Total	**98**			

Table 2 shows that students taught with AI-based instructional systems performed better academically, with a mean score of 76.80**,** compared to 63.40 for those taught using traditional methods. The mean difference of 13.40 indicates that AI-based learning has a significant effect on enhancing students' academic performance. Adaptive learning, personalized feedback, and interactive practice contributed to improved mastery of Computer Science content.

Research Question Three: In what ways do AI-based learning systems enhance students' engagement and motivation in Computer Science classes?

Table 3: Mean and Standard Deviation for Engagement and Motivation

Group	N	Mean	S.D	Mean Difference
Experimental (AI-based)	50	79.50	12.20	10.40
Control (Non-AI)	48	69.10	11.75	
Total	98			

The findings in Table 3 indicate that students in the AI-based group scored higher on engagement and motivation **(**79.50**)** than their counterparts in the traditional group (**69.10**). The mean difference of 10.40 shows that AI-supported learning environments promote increased participation, interest, and enthusiasm. Interactive elements such as gamification, simulations, and personalized guidance likely contributed to these improvements.

Research Question Four: How do students who use AI-based learning systems compare to those using traditional methods in terms of Computer Science performance outcomes?

Table 4: Mean and Standard Deviation for Performance Outcomes

Group	N	Mean	S.D	Mean Difference
Experimental (AI-based)	50	81.40	9.40	12.20
Control (Traditional)	48	69.20	10.60	
Total	98			

Table 4 shows that students using AI-based learning systems achieved a mean score of 81.40**,** while those taught through traditional instruction scored 69.20. The mean difference of 12.20 indicates that AI-based learning systems lead to superior performance outcomes. AI tools

improved students' ability to understand, apply, and evaluate Computer Science concepts during assessments.

Test of Null Hypotheses

HO_1: There is no significant difference in the understanding and retention of Computer Science concepts between students who engage with AI-based learning systems and those who do not.

Table 5: The t-test analysis for understanding and retention.

Group	N	Mean	S.D	S.E. Mean	T-Cal	DF	T-Critical	Remark
Experimental (AI-based)	50	74.20	10.80	1.53	5.12	96	1.98	Reject HO1
Control (Non-AI)	48	63.10	11.25	1.59				
Total	**98**							

The result in Table 5 shows that the calculated t-value (5.12) exceeds the critical t-value (1.98) at the 0.05 level of significance at 98 degrees of freedom. Consequently, the null hypothesis (HO1), which states that there is no significant difference in understanding and retention between students taught with AI-based learning systems and those taught without AI, is rejected. This implies that the use of AI-based instructional systems significantly enhances students' understanding and retention of Computer Science concepts. The higher mean score recorded by the experimental group (74.20), compared to the control group (63.10), demonstrates that AI-assisted learning provides more effective instructional support, leading to improved cognitive outcomes among students.

HO_2: There is no significant difference in academic performance in Computer Science between students exposed to AI-based learning systems and those who are not

Table 6: t-test analysis for academic performance

Group	N	Mean	S.D	S.E. Mean	T-Cal	DF	T-Critical	Remark
Experimental (AI-based)	50	76.80	9.95	1.41	6.02	96	1.98	Reject HO2
Control (Non-AI)	48	63.40	10.15	1.43				
Total	**98**							

The result presented in Table 6 indicates that the calculated t-value of 6.02 is substantially higher than the critical t-value of 1.98 at the 0.05 level of significance with 98 degrees of freedom. Based on this, the null hypothesis (HO_2), which states that there is no significant difference in academic performance between students taught with AI-based instruction and those taught without AI, is rejected. This finding reveals that AI-based instructional methods have a significant positive effect on students' academic performance in computer science. The experimental group recorded a notably higher mean score of 76.80 compared to the control group's mean of 63.40. This difference demonstrates that AI-supported learning environments enhance students' mastery of course content, likely due to features such as personalized feedback, adaptive learning pace, and interactive instructional tools.

HO_3: There is no significant difference in engagement and motivation between students using AI-based learning systems and those taught without such systems

Table 7: t-test analysis for engagement and motivation

Group	N	Mean	S.D	S.E. Mean	T-Cal	DF	T-Critical	Remark
Experimental (AI-based)	50	79.50	12.20	1.73	4.28	96	1.98	Reject HO3
Control (Non-AI)	48	69.10	11.75	1.66				
Total	98							

The result in Table 7 shows that the calculated t-value of 4.28 is greater than the critical t-value of 1.98 at the 0.05 level of significance with 98 degrees of freedom. Based on this comparison, the null hypothesis (HO_3), which states that there is no significant difference in engagement and motivation between students taught with AI-based learning systems and those taught without AI, is rejected. This means the difference observed between the two groups is statistically significant. The experimental group recorded a mean score of 79.50, which is notably higher than the control group's mean of 69.10. This suggests that students exposed to AI-based instructional tools demonstrate higher levels of engagement and motivation. AI learning environments often include interactive interfaces, multimedia content, personalized learning pathways, and instant feedback, all of which contribute to sustaining students' interest and encouraging active involvement in learning tasks. The higher mean score in the experimental group, therefore, confirms that AI tools enhance learner motivation and create more engaging classroom experiences compared to traditional instruction.

HO_4: There is no significant difference in assessment scores in Computer Science between students taught with AI-based learning systems and those taught using traditional instructional methods

Table 8: t-test Analysis for Assessment Scores

Group	N	Mean	S.D	S.E. Mean	T-Cal	DF	T-Critical	Remark
Experimental (AI-Based)	50	81.40	9.40	1.33	5.44	96	1.98	Reject HO4
Control (Traditional)	48	69.20	10.60	1.50				
Total	**98**							

The results presented in Table 8 show that the calculated t-value (T-cal = 5.44) is significantly higher than the critical t-value (T-critical = 1.98) at the 0.05 level of significance. Because the calculated value exceeds the critical value, the null hypothesis (H0) stating that there is no significant difference in assessment scores between the two groups is rejected.

This implies that students who were taught using AI-based learning systems performed significantly better in Computer Science assessments than those taught through traditional instructional methods. The higher mean score of the experimental group (81.40) compared to the control group's mean score (69.20) further supports the conclusion that AI-assisted instruction has a notable positive effect on students' assessment outcomes.

Discussion of Findings

The findings of this study revealed that the integration of AI-based learning systems significantly enhanced students' understanding, retention, engagement, motivation, academic performance, and assessment outcomes in Computer Science. The results consistently showed that students exposed to AI-enhanced instructional tools outperformed those taught using traditional or non-AI methods across all measured variables. This aligns with recent empirical evidence demonstrating the transformative role of artificial intelligence in modern education.

The study found a significant difference in students' understanding and retention of Computer Science concepts, with the AI-based group achieving higher mean scores. This supports the findings of Li and Wang (2022), who reported that AI-driven learning platforms promote deeper conceptual understanding through adaptive feedback and personalized instruction. Similarly, Ogunleye and Adeyemi (2023) found that AI-supported learning environments enhance cognitive retention by presenting content in interactive and learner-specific formats. The results of this study, therefore, reinforce the argument that AI improves knowledge retention by tailoring instruction to individual learning needs.

The study's findings revealed that students' overall academic performance was significantly improved when AI-based tools were employed. This aligns with the findings of Sarkar and Gupta (2021), who noted that AI-powered learning analytics enhance student achievement by identifying learning gaps and providing targeted practice. Additionally, Musa and Ibrahim (2024) observed that students exposed to AI-embedded classroom activities demonstrated higher academic outcomes due to increased access to real-time corrective feedback and automated assessment features. These studies corroborate the present finding that AI fosters improved academic achievement in Computer Science.

The study's findings revealed that students using AI-based learning systems displayed significantly higher levels of engagement and motivation. This finding is consistent with Huang et al. (2023), who argue that AI-based gamified learning applications stimulate students' interest and sustain their motivation by incorporating interactive multimedia and reward mechanisms. Likewise, Adebayo and Nwosu (2022) found that AI-enabled instructional environments provide dynamic and collaborative learning experiences that keep students actively involved. Therefore, the increased engagement observed among the experimental group in this study reflects the motivational power of AI in enriching students' learning experiences.

The findings indicated a significant improvement in assessment scores among students taught with AI-enhanced systems compared to those taught traditionally. According to Chukwuma and Bello (2023), AI-facilitated assessment tools generate more accurate, timely, and learner-specific evaluations, enabling students to improve rapidly. Similarly, Rahman and Singh (2024) confirmed that AI-adaptive testing increases learners' performance by adjusting question difficulty and offering immediate remediation. The present study's outcome aligns with these findings,

demonstrating that AI plays a critical role in improving students' performance on formal assessments.

Overall, the findings strongly suggest that AI-based learning systems contribute positively and significantly to multiple dimensions of students' learning outcomes in Computer Science. Consistent with the literature, the study reinforces the view that AI technologies have the potential to revolutionize instructional delivery, enhance learner engagement, and improve academic achievement in secondary and tertiary education settings.

Conclusion

This study examined the influence of AI-based learning systems on students' understanding, retention, engagement, motivation, academic performance, and assessment outcomes in Computer Science. The findings clearly demonstrate that AI-supported instructional strategies significantly enhance learning compared to traditional teaching methods. Students exposed to AI tools showed superior understanding of concepts, higher motivation and engagement, improved academic performance, and better assessment scores.

These results affirm that AI-based learning creates an adaptive, interactive, and student-centered environment that supports deeper learning and fosters improved educational outcomes. The study concludes that integrating AI technology into Computer Science instruction is an effective and transformative approach, capable of improving learners' cognitive development and overall academic success. Therefore, embracing AI in secondary school teaching practices is not only beneficial but necessary in meeting the demands of modern, technology-driven education.

Recommendations

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

1. Teachers should integrate AI-based learning systems into routine classroom instruction to strengthen students' comprehension and long-term retention.
2. Schools should adopt AI-assisted instruction as a complementary method to traditional teaching to enhance academic achievement.
3. School administrators should provide access to devices (tablets/computers) that enable effective interaction with AI-based tools.
4. Examination bodies should explore AI-based test preparation systems to boost students' readiness and confidence.

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