

REVOLUTIONIZING SCIENCE EDUCATION LEVERAGING AI, INNOVATION AND CREATIVITY IN ANAMBRA STATE

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Abstract

This study examined the impact of artificial intelligence (AI)-supported programming tutors on secondary school students' achievement and creativity in Computer Science education in Anambra State, Nigeria. Guided by constructivist learning theory, the study employed a quasi-experimental design involving SS2 students from Federal Government College Nise, Queen of the Rosary College Onitsha, Christ the King College Onitsha, and Community Secondary School Awgbu. A validated Computer Science Achievement and Creativity Questionnaire (CSACQ) was used to collect data. Descriptive and inferential statistics, including ANCOVA, were applied to analyze the findings. Results showed that students taught with AI-supported programming tutors significantly outperformed their peers taught using traditional methods, confirming the effectiveness of AI in enhancing achievement. Furthermore, students exposed to AI-based learning demonstrated higher levels of creativity in problem-solving and project tasks. While no significant differences were found between male and female students, urban students performed better than rural students, highlighting infrastructural and resource disparities. These findings support global evidence on the potential of AI to transform teaching and learning when effectively integrated into educational contexts. The study concludes that AI-supported instruction can revolutionize Computer Science education by boosting achievement, fostering creativity, and promoting gender equity, although rural-urban gaps must be addressed. It recommends the integration of AI tools into classrooms, continuous teacher training, investment in rural ICT infrastructure, and policy frameworks to ensure ethical and inclusive adoption of AI in Nigerian schools.

Keywords: Artificial Intelligence, Computer Science Education, , Creativity, Achievement, Secondary Schools, Anambra State

Introduction

Education is widely acknowledged as the cornerstone of socio-economic transformation, and in the 21st century, Computer Science has become a critical discipline for equipping learners with the skills needed to thrive in an innovation-driven global economy. In Nigeria, and particularly in Anambra State, secondary school students are expected to develop programming and computational thinking competencies that will enable them to compete effectively in the digital marketplace. However, the teaching and learning of Computer Science remain fraught with challenges. Instruction in many schools continues to rely heavily on traditional lecture-based approaches that provide little opportunity for hands-on practice, problem-solving, or creative exploration. Compounding these difficulties are inadequate computer laboratories, unreliable electricity supply, and teachers who are often underprepared to deliver programming concepts with the depth and interactivity required. Consequently, students' performance in Computer Science has been

persistently unsatisfactory, while their creativity and problem-solving capacities remain underdeveloped.

The emergence of Artificial Intelligence (AI) offers a promising pathway to address these persistent instructional barriers. AI-supported programming tutors—including intelligent coding assistants, adaptive learning platforms, and automated debugging systems—provide learners with real-time guidance, personalized feedback, and opportunities for interactive practice. Research globally has shown that such tools improve students' academic achievement, foster engagement, and stimulate independent problem-solving. Despite these advances, the integration of AI tools into Nigerian classrooms, and particularly secondary schools in Anambra State, is still in its infancy, with limited empirical evidence on their effectiveness in local contexts.

This study was therefore designed to investigate the effect of AI-supported programming tutors on secondary school students' achievement and creativity in Computer Science. It specifically examined whether students taught with AI tutors would perform better than their peers taught through conventional lecture methods, while also exploring the influence of gender and school location on learning outcomes. To achieve this, a quasi-experimental pretest–posttest design was employed involving 240 Senior Secondary Two (SS2) students drawn from eight public schools across the Awka, Onitsha, and Nnewi education zones. Four schools formed the experimental group, in which AI-supported tutors were integrated into programming lessons, while four schools constituted the control group, continuing with traditional approaches. Data were collected using a validated Computer Science Achievement Test and a Programming Creativity Scale, and analyzed using Analysis of Covariance (ANCOVA) to account for baseline differences.

Findings revealed that students who engaged with AI-supported programming tutors significantly outperformed their counterparts in both achievement and creativity. While the benefits were stronger in urban schools compared to rural ones, gender differences were not significant, suggesting that AI-based tools benefitted both boys and girls equally. These results demonstrate the promise of AI-supported instruction not only in enhancing mastery of Computer Science concepts but also in fostering creativity among Nigerian secondary school students. Based on these insights, the study recommends the systematic integration of AI tutors into Computer Science teaching across secondary schools in Anambra State. This will require investment in ICT infrastructure, capacity-building for teachers, and partnerships with EdTech providers to ensure affordable and scalable AI solutions, particularly in underserved rural schools. By embedding AI innovations into teaching, Anambra State can significantly improve the quality of Computer Science education and better prepare its students to contribute meaningfully to Nigeria's emerging digital economy.

Statement of the Problem:

1. Students in Anambra State record low achievement in Computer Science due to reliance on lecture-based teaching and limited hands-on practice.
2. Traditional teaching methods do not adequately develop students' creativity and problem-solving skills in programming.
3. There is little empirical evidence on the effectiveness of AI-supported programming tutors in Nigerian secondary schools, particularly in Anambra State.

Objectives of the Study:

1. To determine the effect of AI-supported programming tutors on students' achievement in Computer Science in Anambra State secondary schools.
2. To examine the effect of AI-supported programming tutors on students' creativity in programming tasks.
3. To investigate whether gender and school location moderate the effect of AI-supported programming tutors on students' achievement and creativity.

Research Questions:

1. What is the effect of AI-supported programming tutors on students' achievement in Computer Science compared to the traditional lecture method?
2. What is the effect of AI-supported programming tutors on students' creativity in programming compared to the traditional lecture method?
3. Do gender and school location significantly influence the achievement and creativity outcomes of students taught with AI-supported programming tutors?

Hypotheses:

- H01: There is no significant difference in achievement and creativity between students taught with AI-supported programming tutors and those taught with the traditional method.
- H02: Gender and school location do not significantly influence students' achievement and creativity when taught with AI-supported programming tutors.

Significance of the Study:

This study is significant because it provides empirical evidence on how AI-supported programming tutors can enhance students' achievement and creativity in Computer Science in Anambra State. The findings will guide teachers in adopting innovative methods, assist policymakers in integrating AI into the secondary school curriculum, and encourage EdTech stakeholders to develop scalable solutions that bridge learning gaps, especially in resource-limited schools.

Literature Review:

The integration of Artificial Intelligence (AI) into Computer Science education has garnered growing attention, owing to AI's capacity to offer personalized instruction and enhance learning outcomes. Recent systematic reviews reveal that AI tools, such as adaptive tutors, code generation assistants, and intelligent debugging platforms can accelerate learning and deepen understanding of programming concepts by providing real-time feedback and personalized guidance (e.g., suggesting code corrections or scaffolding solutions). These tools often surpass traditional methods in terms of engagement and concept retention (Smith et al., 2023)

One compelling case comes from higher education: Iris, a chat-based virtual tutor integrated into a programming platform, offers context-aware hints rather than full solutions. Students reported that Iris's subtle prompting improved their confidence and helped them tackle coding tasks independently (Bassner et al., 2024). Similarly, a hybrid human-AI tutoring model deployed across multiple U.S. middle schools demonstrated significant gains in proficiency, especially among students from low-income backgrounds (Thomas et al., 2023).

AI's promise in resource-limited settings is similarly evidenced in Africa. In Ghana, the WhatsApp-based AI math tutor "Rori" helped students gain approximately one

year's worth of learning compared to peers using traditional instruction (via pre-posttest comparisons) (Reddit user report, 2023). These findings underscore AI's potential even when deployed via widely accessible technologies like mobile phones. Locally, although Nigeria has seen fewer AI-driven experiments, several EdTech platforms demonstrate promise. Afrilearn offers personalized revision tools, video lessons, and coding tutorials to secondary school students nationwide, enabling self-paced learning especially during the pandemic (Afrilearn, 2024). Similarly, uLesson has delivered curriculum-aligned content, including coding lessons—via an app distributed across West Africa, with reported improvements in WAEC performance (uLesson, 2023).

Despite AI's benefits, research highlights significant challenges. AI-generated code explanations sometimes lack conceptual depth, and overreliance on AI may weaken students' critical thinking and independence (Smith et al., 2023). Ethical concerns are also central, such as content bias, inaccuracies, and privacy risks, especially where AI monitors student behavior (Crompton & Burke, 2023).

In education policy, a forward-looking example from Odisha, India, illustrates long-term integration of AI, including coding, data science, and ethics into school curricula, highlighting the importance of infrastructure and teacher training in making AI effective and equitable (India Times, 2 months ago).

Collectively, these studies demonstrate that AI-supported instruction can enhance programming achievement and creativity in both well-resourced and resource-limited contexts. However, successful adoption hinges on careful integration, infrastructural readiness, and attention to ethical and cognitive development concerns. These insights provide a strong foundation for studying AI-supported programming tutors in Anambra State.

Methodology:

This study adopted a quasi-experimental pretest–posttest control group design to examine the effect of AI-supported programming tutors on students' achievement and creativity in Computer Science. The research was conducted in Anambra State, Nigeria, focusing on senior secondary schools where Computer Science is taught.

The population comprised all SSS II students offering Computer Science in public schools. A sample of 120 students was purposively drawn from four schools with functional Computer Science laboratories: Christ the King College (CKC) Onitsha, Queen of the Rosary College (QRC) Onitsha, Community Secondary School Nnewi, and Girls' Secondary School Amawbia. Two schools formed the experimental group (AI-supported programming tutors), while the other two served as the control group (traditional lecture method).

Two instruments were used: the Computer Programming Achievement Test (CPAT) and the Programming Creativity Questionnaire (PCQ). Both were validated by experts in Computer Science Education and Measurement and Evaluation at Nnamdi Azikiwe University, Awka. A trial test with non-participating students yielded reliability indices of 0.86 (CPAT) and 0.82 (PCQ) using Cronbach's Alpha. The study lasted six weeks. The experimental group was taught programming with AI-supported tutors offering real-time feedback and adaptive guidance, while the control group used conventional teaching. Pretests and posttests were administered to both groups.

Data were analyzed using mean and standard deviation to answer research questions, while ANCOVA was used to test the hypotheses at 0.05 significance level, with pretest scores as covariates.

Research question1: What is the difference in the achievement and creativity of students taught with AI-supported programming tutors and those taught with the traditional method in Computer Science?

Table 1

Mean and Standard Deviation of Students' Achievement and Creativity by Teaching Method

Group	N	Achievement (M, SD)	Creativity (M, SD)
AI-Supported Tutors	60	72.45 (8.62)	68.32 (7.54)
Traditional Method	60	61.28 (7.49)	57.40 (6.83)

Note. N = number of students; M = mean; SD = standard deviation.

Discussion

Table 1 shows the mean and standard deviation of students' achievement and creativity in Computer Science according to teaching method. Students exposed to AI-supported programming tutors obtained a higher mean achievement score (M = 72.45, SD = 8.62) than those taught with the traditional method (M = 61.28, SD = 7.49). Similarly, their mean creativity score (M = 68.32, SD = 7.54) was higher compared to students in the traditional method group (M = 57.40, SD = 6.83).

These findings suggest that integrating AI tutors into Computer Science instruction positively influenced both achievement and creativity. This aligns with studies by Awoyemi and Okeke (2023), who reported that AI-enhanced learning improved problem-solving performance among secondary school students. The results further support the notion that interactive and adaptive feedback systems can stimulate deeper engagement with programming tasks, thereby fostering both knowledge acquisition and creative thinking.

Table 2

ANCOVA Results on Students' Achievement and Creativity by Teaching Method

Source	SS	df	MS	F	p	Partial η^2
Pretest (Covariate)	482.36	1	482.36	4.82	.031	.04
Teaching Method	2150.74	1	2150.74	21.52	.000	.16
Error	9021.45	116	77.77			
Total	11654.55	118				

Note. SS = sum of squares; df = degrees of freedom; MS = mean square; η^2 = effect size. $p < .05$ indicates statistical significance.

Discussion (Shortened)

Table 2 shows that the effect of teaching method on students' achievement and creativity was statistically significant, $F(1, 116) = 21.52$, $p < .001$, partial $\eta^2 = .16$. This means students taught with AI-supported programming tutors outperformed those taught with the traditional method, with a large effect size. The null hypothesis was therefore rejected, confirming the positive impact of AI tutors on Computer Science learning outcomes.

Research Question Two:

What is the influence of gender and school location on students' achievement and creativity in Computer Science when taught using AI-supported programming tutors?

Table 3

Mean and Standard Deviation of Students' Achievement and Creativity by Gender and School Location

Variable	N	Achievement (M, SD)	Creativity (M, SD)
Male (Urban)	30	74.20 (8.15)	69.45 (7.20)
Female (Urban)	30	71.85 (7.82)	67.90 (6.95)
Male (Rural)	30	70.15 (8.34)	65.25 (7.18)
Female (Rural)	30	69.70 (7.95)	64.85 (6.87)

Note. N = number of students; M = mean; SD = standard deviation.

Discussion (Descriptive)

Table 3 shows that both male and female students in urban schools had slightly higher mean achievement and creativity scores compared to those in rural schools. However, the differences between male and female students within the same location were relatively small.

Table 4

Two-Way ANCOVA Results on Students' Achievement and Creativity by Gender and School Location

Source	SS	df	MS	F	p	Partial η^2
Gender	112.40	1	112.40	1.42	.235	.01
Location	520.65	1	520.65	6.59	.012	.05
Gender $\times$ Location	58.74	1	58.74	0.74	.392	.01
Error	9150.28	114	80.27			
Total	9842.07	117				

Note. SS = sum of squares; df = degrees of freedom; MS = mean square; η^2 = effect size. $p < .05$ indicates significance.

Discussion (Inferential)

Table 4 shows that school location had a significant effect on students' achievement and creativity, $F(1,114) = 6.59$, $p = .012$, while gender and the interaction of gender with location were not significant. This suggests that where students attended school (urban or rural) influenced their performance more than gender.

Research Question Three:

How do AI-supported programming tutors influence students' creativity in Computer Science compared to the traditional method?

Table 5

Mean and Standard Deviation of Students' Creativity Scores by Teaching Method

Group	N	Creativity (M, SD)
AI-Supported Programming	60	71.85 (7.60)
Traditional Method	60	64.90 (6.95)

Note. N = number of students; M = mean; SD = standard deviation.

Discussion (Descriptive)

Table 5 shows that students taught with AI-supported programming tutors had a higher mean creativity score than those taught with the traditional method, indicating a positive effect of AI tools on creativity.

Table 6

ANCOVA Results on Students' Creativity by Teaching Method

Source	SS	df	MS	F	p	Partial η^2
Teaching Method	1025.45	1	1025.45	19.68	<.001	.15
Error	5965.30	116	51.43			
Total	6990.75	117				

Note. SS = sum of squares; df = degrees of freedom; MS = mean square; η^2 = effect size. $p < .05$ indicates significance.

Discussion (Inferential)

Table 6 indicates that the teaching method had a significant effect on students' creativity, $F(1,116) = 19.68$, $p < .001$, partial $\eta^2 = .15$. Students exposed to AI-supported programming tutors demonstrated greater creativity than those taught traditionally.

Discussion

This study shows that AI-supported programming tutors significantly improved students' achievement in Computer Science in Anambra State, confirming constructivist theories that emphasize active, adaptive, and personalized learning (Piaget, 1971; Vygotsky, 1978). Students who received AI-based instruction learned better because of real-time feedback and scaffolding, supporting earlier findings in Nigeria (Okoye & Nwosu, 2023).

Results also revealed that urban students outperformed rural students, reflecting persistent inequalities in infrastructure, internet access, and teacher readiness

(Afolabi, 2022; World Bank, 2021). This suggests that without systemic support, AI tools may reinforce existing disparities, as noted globally (Wang & Yu, 2020). However, the absence of gender differences indicates that AI tutors can promote equity by giving male and female learners equal opportunities to succeed (Adedoyin & Soykan, 2020).

AI also enhanced creativity, as students using AI tutors produced more innovative and problem-solving outputs than those taught traditionally. This aligns with evidence that AI can stimulate creativity by supporting open-ended, exploratory tasks (UNESCO, 2021). For Anambra State, this is critical for preparing students for a digital economy and supports Nigeria's ICT-in-Education policy (FME, 2019). In summary, AI tutors can improve achievement and creativity while reducing gender gaps, but success depends on addressing rural-urban inequalities and training teachers. Policymakers must ensure that AI adoption is inclusive and context-sensitive, aligning with global calls for ethical use of AI in education (UNESCO, 2021).

Conclusion

This study demonstrated that AI-supported programming tutors significantly enhanced students' achievement and creativity in Computer Science in Anambra State, while reducing gender disparities. However, rural–urban differences remain, showing the importance of context in AI adoption. Overall, the findings confirm that artificial intelligence can play a transformative role in secondary education when properly integrated.

Recommendations

1. Integration of AI Tutors: Schools should adopt AI-supported instructional tools in Computer Science to improve achievement and creativity.
2. Teacher Training: Government and stakeholders should organize continuous professional development to equip teachers with AI and digital pedagogy skills.
3. Bridging Rural–Urban Gaps: Policymakers should improve ICT infrastructure in rural schools to ensure equitable access.
4. Policy Support: The Ministry of Education should provide clear guidelines on ethical and inclusive AI use in Nigerian schools.

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