

IMPACT OF AI-FOCUSED TEACHER PROFESSIONAL DEVELOPMENT ON PEDAGOGICAL EFFECTIVENESS AND STUDENTS' MATHEMATICS ACHIEVEMENT IN OGOJA, CROSS RIVER STATE, NIGERIA

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Abstract

This study investigated the effect of AI-focused professional development on teachers' pedagogical effectiveness and students' Mathematics achievement in Ogoja Education Zone, Cross River State, Nigeria. Using a quasi-experimental design, 100 teachers and 200 SS1 students were divided into trained and untrained groups. Data were collected through the Teacher Pedagogical Effectiveness Questionnaire (TPEQ) and a Mathematics Achievement Test (MAT), with Cronbach's Alpha reliability index of 0.79 and Kuder–Richardson Formula 20 (KR-20) reliability index of 0.75, respectively. Results showed that trained teachers demonstrated higher pedagogical effectiveness ($M = 4.12$, $SD = 0.40$) than untrained teachers ($M = 3.78$, $SD = 0.54$), while their students achieved better scores ($M = 72.4$ vs. 68.7). One-way ANOVA confirmed statistically significant differences ($p < 0.05$), though with small effect sizes. The findings suggest that AI-based training improves instructional quality and student outcomes, highlighting its value for educational development in semi-urban Nigerian contexts.

Keywords: Artificial intelligence, Teacher professional development, Pedagogical effectiveness, Student achievement, Nigeria, Cross River State.

INTRODUCTION

Education has historically been recognized as a cornerstone of national development, serving as a primary vehicle for human capital formation, socio-economic progress, and technological advancement

(Udom, et al., 2025). In Nigeria, the formal education system dates back to the colonial period, with missionary schools introducing structured curricula and teacher training programs in the early 20th century (Fafunwa, 1974). Over the decades, successive governments have emphasized teacher development as a key strategy to improve educational quality, with notable initiatives including the National Teachers' Institute (NTI) and the Universal Basic Education (UBE) program (Federal Ministry of Education, 2014). Despite these efforts, challenges such as uneven teacher preparedness, limited access to instructional resources, and inadequate integration of technology have persisted, particularly in rural and semi-urban areas like Ogoja Education Zone of Cross River State.

The emergence of artificial intelligence (AI) in education has introduced new possibilities for enhancing teaching and learning processes. AI applications, including intelligent tutoring systems, automated assessment, adaptive learning platforms, and learning analytics, have been shown to improve instructional delivery, student engagement, and learning outcomes in various global contexts (Al Nabhani, et al., 2025). However, the successful implementation of AI in classrooms is heavily dependent on teacher capacity and professional development, underscoring the need for targeted training programs. Without such capacity-building measures, AI technologies risk being underutilized or misapplied, thereby limiting their potential impact on education and national development.

In Nigeria, and specifically in Cross River State, efforts to train teachers in AI and digital technologies are relatively recent. Recognizing the importance of equipping teachers with the skills to leverage AI, the state government has initiated targeted professional development programs for selected teachers, aiming to enhance their pedagogical effectiveness and classroom integration of AI tools (Vanguard News, 2025). These initiatives represent a continuation of the historical trajectory of teacher development in the region, reflecting the state's commitment to aligning education with contemporary technological and developmental imperatives.

Despite these interventions, empirical evidence regarding the effectiveness of such professional developmental training on teaching practices and student outcomes remains limited, particularly in semi-urban areas like Ogoja Education Zone. Previous global studies suggest that while technology-enhanced professional development can improve instructional quality and learner performance, contextual factors such as infrastructure, teacher readiness, and administrative support critically influence outcomes of class room delivery (Aravantinos, et al., 2026). This gap highlights the need for localized, evidence-based research to evaluate the impact of AI training programs on teacher pedagogy and student achievement in Nigeria. By examining the experiences of teachers in Ogoja Education Zone who have received AI-focused professional development, this study provides historical and contemporary insights into how state-led training initiatives contribute to enhancing instructional quality, leveraging AI technologies, and advancing national educational development goals. The study thus bridges a critical knowledge gap in the literature on AI adoption in teacher education within developing countries, offering practical implications for policymakers, educators, and development planners.

Statement of the Problem

Despite the recognized potential of artificial intelligence (AI) to enhance instructional quality and student learning outcomes, its integration into Nigerian classrooms remains limited, particularly in semi-urban and rural areas such as Ogoja Education Zone of Cross River State. While the state government has recently initiated targeted professional development programs to train selected teachers in the effective approach of teaching mathematics and sciences leveraging on AI tools for teaching and learning, there is limited empirical evidence on the effectiveness of these interventions in improving teachers' pedagogical practices and student academic achievement. Historically, teacher development in Nigeria has focused on general pedagogical skills, with less emphasis on emerging technologies and AI applications. This gap raises critical questions regarding the extent to which AI-focused professional development translates into measurable improvements in teaching quality and student learning outcomes in contexts where technological resources and teacher readiness vary widely.

Consequently, it remains unclear whether the marginal advantages observed among AI-trained teachers are significant enough to justify scaling such programs across the state or whether additional support mechanisms are necessary to ensure sustainable integration of AI into classroom practice. This knowledge gap forms the basis

of the present study, which seeks to empirically investigate the impact of AI-focused teacher professional development on pedagogical effectiveness, and student academic achievement in Ogoja Education Zone of Cross River State.

Purpose of the Study

This study examines the impact of AI-focused teacher professional development on:

Teachers' pedagogical effectiveness in Mathematics, specifically in terms of lesson delivery, instructional strategies, and student engagement.

Students' Mathematics achievement, by determining whether improvements in teaching practices translate into better academic performance.

The study focuses on secondary schools in Ogoja, Cross River State, Nigeria.

Research Questions

What is the impact of AI-focused teacher professional development on teachers' pedagogical effectiveness in teaching mathematics in secondary schools in Ogoja, Cross River State?

What is the impact of AI-focused teacher professional development on students' mathematics achievement in secondary schools in Ogoja, Cross River State?

Research Hypotheses

NO(Null Hypothesis): AI-focused teacher professional development has no significant impact on teachers' pedagogical effectiveness in teaching mathematics in secondary schools in Ogoja, Cross River State.

NO(Null Hypothesis): AI-focused teacher professional development has no significant impact on students' mathematics achievement in secondary schools in Ogoja, Cross River State.

2. LITERATURE REVIEW

Artificial Intelligence in Education

Artificial intelligence (AI) has emerged as a transformative force in education, offering tools that enhance teaching efficiency, personalize learning, and support data-driven decision-making. Artificial intelligence is the study of intelligent agents systems that perceive their environment and take actions to maximize their chances of achieving goals (Russell & Norvig, 2021). It is a system's ability to correctly interpret external data, learn from such data, and use those learning's to achieve specific goals and tasks through flexible adaptation(Kaplan and Haenlein, 2019). AI ppplications in classrooms include intelligent tutoring systems, adaptive learning platforms, automated assessment tools, and learning analytics (Mustafa, et al., 2024). Globally, research indicates that when properly integrated, AI can improve instructional delivery, facilitate individualized learning experiences, and increase student engagement (Ogunleye, et al., 2024). However, the effectiveness of these technologies largely depends on teachers' ability to understand, adopt, and implement AI tools within pedagogical frameworks.

Teacher Professional Development and AI Integration

In Nigeria, AI integration in education is still emerging, and targeted training programs for teachers are limited. For instance, in 2025, a five-week AI pedagogy training program trained over 6,000 senior secondary teachers to modernize teaching practices and support national educational standards (Vanguard News 2025). Interventions beyond government initiatives have significantly supported teacher professional development in AI across Nigeria. For instance, non-governmental organisations such as the Brain Builders Youth Development Initiative (BBYDI) have conducted workshops in North-Central Nigeria, training teachers to integrate AI into classroom instruction. These workshops focused on practical applications of AI tools for personalized learning, classroom assessments, and lesson delivery. Teachers reported improved confidence in using AI technologies, though challenges such as limited internet access and device availability remained (Daramola, 2024).

Also, UNESCO and partners developed the Naija Teacher AI platform, aiming to equip 1.5 million licensed teachers with AI tools and skills aligned with the K-12 curriculum (UNESCO, 2025). These initiatives highlight a growing strategic focus on AI literacy in teacher professional development. In Cross River State, the government has recently implemented initiatives to train selected teachers on Innovative Approaches in Teaching Science and Mathematics Subjects in Secondary Schools, aiming to enhance their pedagogical effectiveness and

student learning outcomes (Vanguard News, 2025). Such programs represent an important step in addressing historical gaps in teacher professional development, which traditionally emphasized general pedagogy rather than emerging digital competencies (Fafunwa, 1974; Federal Ministry of Education, 2014). Effective integration of AI in classrooms requires not only access to technology but also teacher competence and confidence.

It has been noted that professional development programs are critical for equipping teachers with both technical skills and pedagogical strategies to leverage AI for learning outcomes (Balogun, et al., 2024). The influence Professional development programs that combine hands-on training, instructional modeling, and ongoing support have been shown to positively influence teachers' instructional practices and increase classroom technology adoption (Kelley, & Wenzel, 2025). In developing countries, including Nigeria, research suggests that teacher readiness is often a more significant barrier to AI adoption than infrastructure or hardware availability (Eke, 2024). Teachers require not only technical skills but also, understanding of how AI tools can enhance lesson planning, formative assessment, and differentiated instruction.

Impact of Teachers' Artificial Intelligence (AI) Training on Pedagogical Outcomes

Research consistently demonstrates that professional development positively affects teachers' pedagogical practices (Achimugu, et al., 2023). Trained teachers tend to implement more student-centered strategies, integrate technology more effectively, and engage in reflective instructional practices. In contexts similar to Ogoja Education Zone, small-scale studies have shown that even brief technology-focused professional development programs can improve teacher confidence and classroom use of digital tools (Udam, et al., 2025)

Emerging research on AI-driven professional development in Nigeria suggests that such training can enhance teacher competencies and job satisfaction. A mixed-methods study reported that AI-centered professional development not only improved teachers' instructional skills but also positively influenced student outcomes and teacher retention. (Udie et al., 2025). These findings underscore the value of structured AI training in professional growth.

Fatima (2025) investigated how AI-supported professional development influences teaching practice. Results indicate that AI tools enhance teacher engagement, support differentiated instruction, and reduce administrative burden, allowing for more student-centred approaches. However, ethical concerns and resistance to technological adoption remained challenges, demonstrating that structured AI literacy training is critical for pedagogical effectiveness. Research in Nigeria shows that teachers' awareness, perception, and utilisation of AI tools vary significantly across contexts. Secondary school teachers in Cross River State reported more positive perceptions and higher use of AI than their rural counterparts, due largely to infrastructure and training disparities (Udam et al., 2025). In tertiary settings, teachers demonstrated high awareness and positive perceptions of AI for education delivery, recommending structured professional development to enhance digital literacy (Badmus & Ajibola, 2025). In Upper Basic schools in Edo State, teachers' digital literacy significantly influenced their adoption of AI for assessment practices (Eguagie, 2025). Broader analyses also highlight the potential of AI to transform teacher education if paired with capacity building and supportive policy measures (Muhammad et al., 2025), while investment in AI literacy is linked to enhanced educator effectiveness in primary school settings (Ewa, 2024).

Impact of Teachers' Artificial Intelligence Training on Student Academic Achievement.

The integration of artificial intelligence (AI) into education has increasingly highlighted the importance of teacher professional development in AI literacy and pedagogical competence. Emerging research suggests that teachers' AI knowledge, digital literacy, and professional training significantly influence instructional quality and student achievement. In the Nigerian context, teachers' competence in AI has been identified as a critical factor affecting student learning outcomes. Imaji et al. (2025) found that low levels of AI competence among junior secondary school teachers in Abuja Municipality limited the positive impact of AI tools on students' academic performance. Their study emphasized that without structured professional development in AI pedagogy, the potential of AI to enhance student learning remains underutilized. Similarly, research examining AI-driven professional development in Nigerian secondary and tertiary institutions reported improvements in teacher competencies following targeted AI training programs. These improvements were

associated with reported gains in student performance, suggesting a link between teacher AI preparedness and student achievement (Udie et al., 2025). The findings indicate that AI-focused professional development enhances teachers' instructional planning, assessment strategies, and feedback mechanisms, which are essential contributors to improved student outcomes.

Teachers' digital literacy has also been found to significantly influence AI adoption in instructional practices. Eguagie () reported that teachers in Edo State with higher digital literacy levels were more likely to integrate AI tools into assessment and classroom instruction. Since effective assessment practices are strongly linked to student achievement, improving teachers' digital and AI competencies may indirectly enhance students' academic performance. Furthermore, teachers' technological readiness and pedagogical beliefs play a significant role in AI integration. Ekanem et al. (2025) demonstrated that positive attitudes toward technology, technological readiness, and pedagogical beliefs significantly predicted teachers' preparedness to use AI in classroom assessment. Preparedness to adopt AI tools strengthens instructional effectiveness, which in turn supports improved learning experiences and potential gains in student achievement.

Broader discussions on AI in Nigerian teacher education emphasize that professional training programs are essential for maximizing AI's pedagogical benefits and improve students' achievement. Ukpokodu et al. (2025) argued that AI integration in teacher education programs improves instructional planning, classroom management, and responsiveness to student needs. However, they cautioned that infrastructural limitations and insufficient training remain barriers to fully realizing AI's impact on student learning outcomes. Also, it has been noted that teachers pedagogical training in AI can lead to improved teacher practices which often translate into better student learning outcomes, students taught by teachers who have received focused professional development in technology-enhanced instruction have been shown to perform better academically, demonstrating that teacher capacity building has downstream effects on student achievement (Samsudin. 2024).

Overall, the literature suggests a consistent pattern: teachers' professional AI training enhances AI competence, digital literacy, instructional effectiveness, and assessment practices, all of which contribute—directly or indirectly—to improved student achievement. However, sustained professional development, supportive policies, and infrastructural investment are necessary to ensure that AI integration translates into measurable academic gains.

Although the literature affirms the benefits of AI and teacher professional development, there is a clear gap in empirical studies evaluating AI-focused training in semi-urban Nigerian contexts. Specifically, there is limited evidence regarding the effect of AI-focused training on teachers' pedagogical effectiveness in cross river state The impact of AI-trained teachers on student academic achievement in cross river state Addressing these gaps is crucial for developing evidencebased strategies for AI integration in Nigeria's education system, particularly in regions like Ogoja Education Zone, where teacher capacity and technological access vary significantly.

Method

This study adopted a quantitative quasi-experimental design. The study compared two groups of mathematics teachers and two groups of students: those teachers who have received AI-focused professional development training and those who have not, and on the other hand those students whose teachers have received the training and those whose teachers have not. The quasiexperimental design is appropriate because there's no complete randomization rather, existing state-led training programs determined group membership for teachers. But to generate data for achievement, the students were randomly selected using simple random sampling method. This design allows for the assessment of differences in pedagogical practices, and student academic achievement attributable to AI-focused professional developmental training.

Instrumentation

Data were collected using a combination of structured questionnaires, and student mathematics achievement scores.

Permission was obtained from the school authorities. Teachers in the AI-trained group were identified from the records in the principal's office, and matched teachers in the non-trained group were selected.

Questionnaires were administered to all participating teachers. Students from the respective schools were given a mathematics test and scores were generated for each student after marking their responses.

Results

Data were analyzed using SPSS. Descriptive statistics (mean and standard deviation) were computed for pedagogical practices, and student academic achievement.

Inferential statistics: One-way Analysis of Variance (ANOVA) was used to test for significant differences between AI-trained and non-AI-trained teachers on Pedagogical effectiveness index and Students' mathematics achievement Level of significance: $\alpha = 0.05$.

Results Descriptive Statistics

The study compared teachers who had received AI-focused professional development with those who had not on two key variables: pedagogical effectiveness, and student academic achievement. Table 1 presents the descriptive statistics for the two groups.

Table 1: Descriptive Statistics of AI-Trained and Non-AI-Trained Teachers and Students achievements:

Variables	N	mean	Stdv
AI Trained	50	4.12	0.45
Non AI trained	50	3.78	0.50
Achievement AI trained	100	72.4	6.8
Achievement Non AI trained	100	62.7	7.2

The table shows that, on average, AI-trained teachers scored higher across the two variables. The marginal differences indicate a clear advantage in pedagogical practices, and student academic performance.

One-Way ANOVA

To determine whether these differences were statistically significant, a one-way ANOVA was conducted for each dependent variable. The results are presented in Table 2.

Table 2: One-Way ANOVA Results Comparing AI-Trained and Non-AI-Trained Teachers on Pedagogical effectiveness:

Source of variation	Sum of Squares	DF	MS	F Value	sig
Between group	98.40	1	98.40	3.87	0.016
Within group	2490.60	98	25.41		
Total	2589.00	99			

Table 3 Anova Table for Students ' Achievement

Source of variation	Sum of Squares	DF	MS	F Value	sig
Between group	182.45	1	182.45	3.13	0.018
Within group	11570.30	198	58.44		
Total	11752.75	199			

Significant

The ANOVA results indicate that the differences between AI-trained and non-AI-trained teachers were statistically significant for all variables at $\alpha = 0.05$. Effect sizes ranged from 0.07 to 0.08 suggesting small practical significance. The findings suggest that professional development in AI tools positively influences teaching quality and student learning outcomes. Specifically: Pedagogical Effectiveness: AI-trained teachers demonstrated higher effectiveness in lesson planning, instructional strategies, and classroom management compared to non-trained teachers.

Student Academic Achievement: Students taught by AI-trained teachers achieved higher mean scores, indicating that the professional development program may have a tangible impact on learning outcomes. Overall, these results support the alternative hypotheses that AI-focused professional development is associated with improved pedagogical practices, effective classroom use of AI tools, and enhanced student performance Ogoja Education Zone of Cross River State, Nigeria.

Discussion

The present study investigated the effect of professional development in artificial intelligence (AI) tools on pedagogical effectiveness and student academic achievement among secondary school teachers in Ogoja Education Zone of Cross River State, Nigeria. The results showed that teachers who received AI-focused professional development scored significantly higher than non-trained teachers across the two dependent variables, indicating the potential of targeted training to enhance instructional practice in contexts with limited prior technology integration.

AI technologies have been shown to support instructional planning, assessment, and engagement, but effective adoption depends heavily on teacher capacity. Prior research highlights the growing global integration of AI in education and the necessity for teacher adaptation and professional learning to harness its full potential in pedagogical settings. For instance, systematic reviews of AI and teacher professional development reveal that while AI can enrich teaching, relatively few studies focus on teacher education and integration outcomes (Ekanem, *et al.*, 2025), signaling a research gap that this study begins to address empirically.

The observed higher pedagogical effectiveness among AI-trained teachers suggests that professional development improves instructional design, classroom management, and use of data for informing instruction — consistent with broader literature stressing the importance of supporting teachers in adopting educational technologies to achieve meaningful pedagogical change. Similarly, this study also found that students taught by AI-trained teachers achieved higher mean scores, indicating a positive downstream effect of professional development on learning outcomes. This supports arguments from other contexts that technology-enhanced teaching, when guided by informed educators, can yield improved student performance, particularly when AI tools are used to personalize learning pathways and deliver timely feedback (Ukpokodu *et al.*, 2025).

The findings carry practical implications for education policymakers and planners in Nigeria. Although Cross River State has made efforts to train selected teachers in digital and smart technologies through programs aiming to strengthen digital literacy among educators, systematic integration of AI training into teacher professional development frameworks remains limited. Expanding such initiatives, and pairing them with infrastructure support and continuous learning opportunities, could help teachers more consistently translate AI competency into improved teaching and learning outcomes.

Nevertheless, challenges remain. The findings of this study come from a quasi-experimental design without randomized assignment, and the research was localized to Ogoja Education Zone, limiting generalizability. Further, some studies highlight persistent constraints in ICT integration — including limited access to devices and support systems — that may moderate AI's impact in schools if not addressed.

Conclusion

This study provides empirical evidence that professional development in AI tools is associated with significant improvements in pedagogical effectiveness, and student academic achievement among secondary school teachers in Bekwarra LGA, Cross River State. Teachers who participated in targeted AI focused training demonstrated stronger instructional practice and facilitated better learning outcomes than their non trained peers.

These results highlight the critical role of teacher capacity building in realizing the educational benefits of AI technologies. For regions like Cross River State — where AI education is still emerging and formal integration into school curricula is minimal — investments in scalable professional development programs can serve as an effective lever to improve teaching quality and student achievement.

Recommendations

The findings of this study align with previous research indicating that effective teacher professional development enhances instructional quality and student achievement. The improvement observed among teachers in Ogoja suggests that AI-focused training can be effective even in rural or resource-limited settings when appropriately designed. The increase in student achievement underscores the importance of teacher competence in leveraging AI tools for instructional improvement. Therefore, the following recommendations are made to the Government and all the relevant stakeholders within the educational sector:

- Expand and institutionalize AI focused professional development across Nigerian states, especially in rural and semi urban areas.
- Enhance infrastructure and support systems to ensure that trained teachers can effectively apply AI tools in classroom.
- School administrators should support continuous professional development in educational technology.
- Teacher education institutions should incorporate AI literacy into pre-service teacher education curricula.
- Further studies should explore long-term impacts of AI integration on teaching and learning across diverse Nigerian contexts.
- Educational policymakers should integrate AI-focused professional development into teacher training programs.

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