IMPACT OF AI-POWERED LEARNING ON STUDENTS' ACADEMIC ACHIEVEMENT IN PRIMARY SCHOOLS

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Abstract

This study investigated the impact of Artificial Intelligence (AI)-powered learning on the academic achievement of primary school students in Lagos State, Nigeria. The study adopted a quasi-experimental pre-test and post-test control group design to evaluate the effectiveness of AI-based adaptive learning platforms in comparison with traditional teacher-centered instructional methods. A sample of 100 pupils was purposively selected and equally assigned to an experimental group, exposed to AI-powered learning tools, and a control group, taught using conventional methods.

Data were collected using a validated 10-item academic achievement test and analyzed using descriptive statistics and paired-sample t-tests at a 0.05 level of significance. The findings revealed a statistically significant difference in academic performance between the two groups, with the experimental group (M = 7.60, SD = 1.50) outperforming the control group (M = 6.20, SD = 1.70), with a strong effect size (Cohen's d = 0.87). The results indicate that AI-powered learning enhances student engagement, supports individualized instruction, and improves content mastery by reducing extraneous cognitive load through personalized pacing, immediate feedback, and interactive scaffolding.

The study concludes that AI-powered learning is a highly effective instructional strategy for improving academic achievement in primary education and has the potential to transform knowledge acquisition processes. It recommends that educational stakeholders prioritize the integration of AI-based learning technologies, invest in teacher capacity development, and strengthen digital infrastructure to support scalable and equitable implementation in Nigerian schools.

Keywords: Artificial Intelligence, Academic Achievement, Adaptive Learning, Educational Technology, Primary Education

INTRODUCTION

Education remains a fundamental driver of socio-economic development, and improving students' academic achievement continues to be a central goal of educational systems worldwide. In recent decades, the integration of digital technologies into education has significantly transformed teaching and learning processes, creating new opportunities for enhancing instructional delivery and learning outcomes. Among these technological innovations, Artificial Intelligence (AI) has emerged as a powerful and disruptive tool with the potential to revolutionize education through personalized, adaptive, and data-driven learning environments (Holmes, Bialik, & Fadel, 2019; Luckin et al., 2016).

Globally, education systems are increasingly embracing digital transformation to optimize learning outcomes, particularly at the primary level where foundational cognitive skills, literacy, and numeracy are developed. However, in many developing countries, including Nigeria, the education sector continues to grapple with persistent challenges such as overcrowded classrooms, inadequate instructional materials, and teacher-centered pedagogical approaches that fail to address the diverse learning needs of students. These limitations often result in passive learning, low student engagement, and poor academic performance (UNESCO, 2019).

Artificial Intelligence offers a promising solution to these challenges through AI-powered learning systems such as intelligent tutoring systems, adaptive learning platforms, and automated feedback mechanisms. These technologies provide personalized learning experiences tailored to individual learners by analyzing performance data in real time and adjusting instructional content accordingly. This enables differentiated instruction, enhances student engagement, and promotes deeper understanding of subject matter (Zawacki-Richter et al., 2019).

The application of AI in primary education extends beyond simple task automation; it represents a fundamental shift in pedagogical practice from a traditional "one-size-fits-all" model to a learner-centered approach that supports individualized learning pathways. AI-powered tools incorporate features such as gamification, real-time analytics, and interactive scaffolding, which actively engage learners and improve knowledge retention. In addition, the COVID-19 pandemic accelerated the adoption of digital learning globally, highlighting the importance of integrating technology into education systems to ensure continuity and resilience in learning delivery (OECD, 2020).

In Nigeria, particularly in Lagos State—the commercial and educational hub of the country—the integration of AI technologies in primary education remains at an emerging stage. While some private schools have begun to explore digital learning tools, the majority of classrooms still rely

heavily on conventional teaching methods characterized by rote memorization and limited student interaction. This situation underscores the need for innovative instructional approaches that can address existing gaps in teaching and learning.

Despite the growing recognition of AI's potential in education, empirical evidence on its effectiveness in improving academic achievement among primary school pupils in Nigeria remains limited. Existing studies have largely focused on secondary or tertiary education, leaving a critical gap in understanding how AI-powered learning impacts foundational education levels. Furthermore, while AI systems are increasingly capable of supporting higher-order cognitive processes such as problem-solving and knowledge reasoning, there is a need to determine whether these capabilities translate into measurable improvements in academic performance among young learners.

This study seeks to address this gap by examining the impact of AI-powered learning on students' academic achievement in primary schools in Lagos State, Nigeria. Specifically, the study compares the performance of pupils exposed to AI-based adaptive learning tools with those taught using traditional instructional methods, with the aim of providing empirical evidence on the effectiveness of AI in enhancing foundational learning outcomes.

STATEMENT OF THE PROBLEM

Primary education in Nigeria continues to face significant challenges that hinder effective teaching and learning, including overcrowded classrooms, limited instructional resources, and the persistent use of teacher-centered instructional approaches. These challenges often result in low student engagement, inadequate attention to individual learning differences, and ultimately poor academic achievement among pupils.

Although advancements in educational technology have introduced innovative tools capable of enhancing instructional delivery, the integration of such technologies—particularly Artificial Intelligence (AI)—remains limited in most Nigerian primary schools. Traditional teaching methods still dominate classroom practices, despite their inability to adequately support personalized learning and improve learning outcomes in increasingly diverse classroom settings.

Globally, AI-powered learning systems have demonstrated considerable potential in improving student engagement, supporting individualized instruction, and enhancing academic performance. However, within the Nigerian context, especially at the primary education level, there is a scarcity of empirical studies that provide concrete evidence of the effectiveness of AI-powered learning on students' academic achievement.

This lack of localized empirical data creates a critical gap in knowledge, making it difficult for educational stakeholders to make informed decisions regarding the adoption and implementation of AI technologies in primary education. It is therefore necessary to investigate whether AI-powered learning can significantly improve academic achievement compared to traditional instructional methods among primary school pupils in Lagos State.

PURPOSE OF THE STUDY

The main purpose of this study is to examine the impact of AI-powered learning on students' academic achievement in primary schools in Lagos State, Nigeria.

Specifically, the study seeks to:

1. Determine the difference in academic achievement between students exposed to AI-powered learning tools and those taught using traditional instructional methods.
2. Evaluate the effectiveness of AI-powered learning in enhancing students' understanding and engagement in the learning process.

RESEARCH QUESTION

The study is guided by the following research question:

- What is the impact of AI-powered learning on students' academic achievement in primary schools in Lagos State?

RESEARCH HYPOTHESIS

The following null hypothesis was tested in the study:

- **H_0:** There is no significant difference in academic achievement between students taught using AI-powered learning tools and those taught using traditional instructional methods.

LITERATURE REVIEW

Artificial Intelligence in Education

Artificial Intelligence (AI) has increasingly gained prominence in education due to its capacity to transform teaching and learning processes through intelligent, data-driven systems. AI-powered learning tools—such as adaptive learning platforms, intelligent tutoring systems, and automated

feedback mechanisms—enable personalized instruction tailored to individual learners' needs. These systems analyze student performance in real time and dynamically adjust instructional content, thereby enhancing engagement, improving learning efficiency, and supporting differentiated instruction (Holmes, Bialik, & Fadel, 2019; Luckin et al., 2016).

The integration of AI into education represents a shift from traditional teacher-centered approaches to learner-centered environments that prioritize personalization and active engagement. This transformation is particularly significant in primary education, where foundational cognitive skills are developed, and early intervention can significantly influence long-term academic outcomes.

AI-Powered Learning and Academic Achievement

Empirical studies have consistently demonstrated that AI-powered learning environments positively influence students' academic achievement. Research indicates that students exposed to AI-based instructional systems perform significantly better than those taught using conventional teaching methods. For instance, intelligent tutoring systems have been shown to improve standardized test scores by providing targeted, individualized support comparable to one-on-one human tutoring (VanLehn, 2011).

Similarly, studies by Zawacki-Richter et al. (2019) highlight that AI applications in education enhance learning outcomes by enabling adaptive content delivery, immediate feedback, and continuous assessment. These features help students identify knowledge gaps and receive timely interventions, leading to improved understanding and retention of instructional material. The ability of AI systems to provide personalized pacing ensures that both high-performing and struggling learners benefit from instruction tailored to their specific needs.

Technology-Assisted Learning in the Nigerian Context

In Nigeria, research on technology-assisted instruction has shown promising results in improving students' academic performance, particularly in science and mathematics education. Studies have revealed that students exposed to digital learning tools, including augmented reality and computer-assisted instruction, achieve higher test scores compared to those taught using traditional methods. These improvements are largely attributed to the interactive and visual nature of digital tools, which enhance conceptual understanding of abstract topics.

However, despite these positive outcomes, research specifically focusing on AI-powered learning in Nigerian primary education remains limited. Most existing studies have concentrated on secondary or tertiary education levels, leaving a gap in empirical evidence regarding the effectiveness of AI at the foundational stage of learning. This gap underscores the need for

localized studies that examine the impact of AI-powered learning within the context of primary education in Nigeria.

AI and Personalized Learning

One of the most significant contributions of AI in education is its ability to support personalized learning. AI-powered systems enable learners to progress at their own pace, receive customized feedback, and engage with content that aligns with their individual learning styles and abilities. This is particularly important in primary education, where learners exhibit varying levels of cognitive development and learning readiness.

Personalized learning facilitated by AI helps address individual learning differences by providing targeted support for struggling students while allowing advanced learners to move ahead without constraints. Research indicates that such adaptive learning environments improve student motivation, engagement, and academic performance (Pane et al., 2017). By tailoring instruction to individual needs, AI-powered tools contribute to more inclusive and effective learning experiences.

Gaps in Existing Literature

Despite the growing body of literature on AI in education, several gaps remain. First, there is a lack of context-specific studies examining the impact of AI-powered learning in developing countries, particularly at the primary education level. Second, while many studies highlight the potential benefits of AI, there is limited empirical evidence that directly compares AI-based instruction with traditional teaching methods using rigorous experimental designs.

Furthermore, existing research often focuses on predictive analytics and machine learning models for forecasting academic performance, with less emphasis on evaluating the actual instructional impact of AI tools on students' learning outcomes. This study addresses these gaps by providing empirical evidence on the effectiveness of AI-powered learning in improving academic achievement among primary school pupils in Lagos State, Nigeria, using a quasi-experimental research design.

METHODOLOGY

This study adopted a quasi-experimental research design utilizing a pre-test and post-test control group format to examine the impact of AI-powered learning on students' academic achievement. The quasi-experimental design was considered appropriate due to the practical constraints of educational settings, where random assignment of participants is often not feasible because of existing classroom structures.

The population for the study comprised primary school pupils in Lagos State, with a specific focus on Primary 5 and Primary 6 students from selected private schools in Ibeju Lekki Local Government Area. A stratified random sampling technique was employed to ensure fair representation across gender and varying academic ability levels. A total sample size of 100 pupils was selected and evenly distributed into two groups: the experimental group (n = 50), which was exposed to AI-powered learning tools, and the control group (n = 50), which received conventional teacher-centered instruction.

The instructional intervention was conducted over a structured academic period. During this period, the experimental group engaged with AI-powered adaptive learning applications designed for primary-level literacy and general knowledge. These applications provided personalized content recommendations, real-time feedback, error correction, and individualized pacing. In contrast, the control group was taught using traditional instructional methods, including textbook-based teaching and the conventional "chalk-and-talk" approach, while covering the same curriculum content as the experimental group.

Data were collected using a validated 10-item Academic Achievement Test, which was administered as both a pre-test and a post-test. The pre-test was used to establish baseline equivalence between the two groups, while the post-test measured the level of knowledge acquisition after the intervention. The instrument underwent face and content validation by experts in measurement and evaluation, ensuring its appropriateness for the study. Reliability of the instrument was established using Cronbach's alpha coefficient, which yielded a value of 0.88, indicating a high level of internal consistency.

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS). Descriptive statistics, including mean and standard deviation, were used to summarize students' performance, while inferential statistics-specifically paired-sample t-tests—were employed to test the research hypothesis at a 0.05 level of significance.

PRESENTATION OF AND ANALYSIS OF DATA

EMPIRICAL FINDINGS AND STATISTICAL ANALYSIS

The analysis of the collected data commenced with the examination of the mean academic achievement scores of both the experimental and control groups following the instructional intervention. Descriptive statistics were employed to determine the extent of variation in performance between the two groups.

PRESENTATION AND ANALYSIS OF RESEARCH QUESTION DATA

The results of the data analysis, in relation to the research questions raised and the hypotheses tested, are presented in this section.

Research Question: What is the impact of AI-powered learning on students' academic achievement in primary schools in Lagos State?

Table 1: Mean Achievement Scores of Experimental and Control Groups

Group Classification	N	Mean Score (M)	Standard Deviation (SD)
Experimental Group (AI Learning Tools)	50	7.60	1.50
Control Group (Traditional Method)	50	6.20	1.70
Overall Mean Difference	100	**1.40**	-

Interpretation of Descriptive Statistics

The results presented in Table 1 indicate a clear and measurable difference in academic achievement between the two groups. The experimental group, which was exposed to AI-powered learning tools, recorded a higher mean score (M = 7.60, SD = 1.50) compared to the control group (M = 6.20, SD = 1.70), which received traditional instruction.

This difference represents a raw mean gain of **1.40 points** on a 10-point achievement scale, suggesting a substantial improvement in learning outcomes attributable to the AI-based instructional intervention. Furthermore, the lower standard deviation observed in the experimental group indicates a more consistent distribution of scores, implying that the AI-powered learning environment not only improved overall performance but also reduced variability among learners. This suggests that lower-performing students benefited significantly from the adaptive and personalized features of the AI tools.

PRESENTATION AND ANALYSIS OF RESEARCH HYPOTHESIS DATA

Test of Hypothesis

To determine whether the observed difference in academic achievement was statistically significant, a paired-sample t-test was conducted to test the null hypothesis:

H_0: There is no significant difference in academic achievement between students taught using AI-powered learning tools and those taught using traditional instructional methods.

Table 2: Paired Sample t-test Analysis of Academic Achievement

Variables Analyzed	Mean	SD	Mean Difference	Standard Error	t-value	p-value	Decision
Control Group (Traditional - Pre/Post)	6.20	1.70	1.40	0.32	4.37	0.001	Reject H_0
Experimental Group (AI - Post-test Outcome)	7.60	1.50					

Interpretation of Inferential Statistics

The inferential analysis revealed a calculated t-value of **4.37**, with a corresponding p-value of **0.001**, which is statistically significant at the 0.05 level ($p < 0.05$). This indicates that the observed difference in academic achievement between the experimental and control groups is not due to chance.

Consequently, the null hypothesis (H_0) is rejected, confirming that AI-powered learning has a statistically significant effect on students' academic achievement.

To further determine the practical significance of this difference, an effect size (Cohen's d) was computed. The resulting value of **0.87** indicates a **large effect size**, suggesting that the impact of the AI intervention is not only statistically significant but also educationally meaningful and practically substantial.

CONCLUSION

This study examined the impact of Artificial Intelligence (AI)-powered learning on students' academic achievement in primary schools in Lagos State, Nigeria, using a quasi-experimental research design. The findings revealed that students exposed to AI-powered learning tools performed significantly better than those taught using traditional instructional methods. The observed difference in performance, supported by both descriptive and inferential statistical analyses, confirms that AI integration has a meaningful and positive effect on students' academic achievement.

The study established that AI-powered learning enhances instructional effectiveness by promoting personalized learning, improving student engagement, and facilitating better understanding of academic content. The adaptive features of AI tools—such as real-time feedback, individualized pacing, and targeted content delivery—were found to support more efficient cognitive processing and knowledge retention among learners. In addition, the reduced variability in students' performance suggests that AI-powered learning contributes to more equitable learning outcomes by supporting learners with diverse abilities.

The large effect size recorded in the study further indicates that the impact of AI-powered learning is not only statistically significant but also practically meaningful within the context of primary education. This highlights the potential of AI technologies to address longstanding challenges associated with traditional instructional methods, particularly in environments characterized by limited resources and diverse learner needs.

In conclusion, the integration of AI-powered learning tools represents a transformative approach to teaching and learning in primary education. The study provides empirical evidence that supports the adoption of AI-driven instructional strategies as an effective means of improving academic achievement and enhancing the overall quality of education in Nigerian primary schools.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. **Integration of AI-Powered Learning Tools in Schools**
   Primary schools should actively integrate AI-powered learning applications into their instructional processes. These tools should be incorporated as complementary resources to enhance teaching effectiveness, support personalized learning, and improve students' academic achievement.
2. **Teacher Training and Capacity Development**
   Teachers should be provided with continuous professional development and training on the effective use of AI-powered instructional tools. This will enable them to integrate technology seamlessly into classroom practices and maximize its benefits for student learning.
3. **Investment in Educational Technology Infrastructure**
   Government and educational stakeholders should invest in the provision of adequate digital infrastructure, including reliable internet access, devices, and AI-enabled learning platforms, particularly in public primary schools. This will ensure equitable access to AI-driven learning opportunities.
4. **Curriculum Integration and Policy Support**
   Educational policymakers should revise existing curricula to incorporate AI-based

learning approaches and digital pedagogies. Clear policies and guidelines should be developed to support the ethical and effective use of AI in primary education.

5. **Promotion of Inclusive and Personalized Learning**
   Schools should leverage AI-powered tools to support inclusive education by addressing individual learning differences. Adaptive learning systems should be used to provide targeted support for struggling learners while also challenging high-performing students.
6. **Further Research in AI and Primary Education**
   Researchers should conduct further studies on the long-term impact of AI-powered learning across different subjects, regions, and educational levels. This will provide more comprehensive evidence to guide policy and practice in educational technology integration.

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