EFFECT OF ARTIFICIAL INTELLIGENCE–DRIVEN PERSONALIZED LEARNING ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT, RETENTION, AND ATTITUDES TOWARD PHYSICS IN ABAK LOCAL GOVERNMENT AREA, AKWA IBOM STATE, NIGERIA

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Abstract: This study investigated the effect of Artificial Intelligence–Driven Personalized Learning (AIDPL) on secondary school students' achievement, retention, and attitudes toward Physics in Abak Local Government Area of Akwa Ibom State, Nigeria. A quasi-experimental pretest–posttest non-equivalent control group design was adopted. The population comprised all Senior Secondary School II (SS II) Physics students in public secondary schools in Abak. A sample of 120 students drawn from two intact classes was used for the study. One class served as the experimental group and was taught using AI-driven personalized learning, while the control group was taught using the conventional lecture method. Three instruments were used for data collection: Physics Achievement Test (PAT), Physics Retention Test (PRT), and Students' Attitude toward Physics Questionnaire (SAPQ). The instruments were validated by experts and their reliability indices ranged from 0.78 to 0.86. Mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The findings revealed that students exposed to AI-driven personalized learning performed significantly better in achievement and retention and demonstrated more positive attitudes toward Physics than those taught using the conventional method. The study concludes that AI-driven personalized learning enhances students' learning outcomes in Physics and recommends its integration into secondary school Physics instruction.

Introduction

Physics is a core science subject that underpins technological advancement, scientific literacy, and national development. At the secondary school level, Physics is expected to equip learners with problem-solving skills, conceptual understanding, and positive scientific attitudes necessary for further studies and careers in science and technology. However, despite its importance, students' achievement in Physics in Nigerian secondary schools has remained persistently low. Several studies have attributed this trend to the abstract nature of Physics concepts, ineffective instructional methods, limited learner engagement, and negative attitudes toward the subject (Aina & Akintunde, 2013; Okoronka & Wada, 2014).

Traditional teacher-centred instructional approaches commonly used in Physics classrooms often fail to address individual differences in students' learning abilities, pace, and prior knowledge. As a result, many students experience difficulties in understanding concepts, leading to poor achievement and weak retention of learned materials. Empirical evidence has shown that learner-centred and individualized instructional strategies significantly enhance students' academic achievement and engagement in Physics. For instance, Utibe, Uboh, and Inyang

(2022) reported that individualized and cooperative learning strategies produced significant improvements in secondary school students' achievement in Physics, emphasizing the importance of instructional approaches that respond to learners' individual needs.

Recent advances in educational technology, particularly Artificial Intelligence (AI), have provided new opportunities for implementing individualized instruction at scale. Artificial Intelligence in education refers to the use of intelligent systems capable of mimicking human cognitive functions such as reasoning, decision-making, and adaptive feedback to support teaching and learning processes (Luckin et al., 2016). One of the most promising applications of AI in education is Artificial Intelligence–Driven Personalized Learning, which involves tailoring instructional content, learning pace, assessment, and feedback to the specific needs of individual learners (Holmes, Bialik, & Fadel, 2019).

AI-driven personalized learning environments use data from learners' interactions to diagnose strengths, weaknesses, and misconceptions, thereby providing adaptive learning pathways that promote deeper understanding. Studies have demonstrated that personalized learning supported by intelligent systems improves students' academic achievement and retention by fostering active engagement, self-regulated learning, and continuous feedback

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(Pane et al., 2017; Kulik & Fletcher, 2016). In Physics education, where conceptual understanding and problem-solving are critical, AI-driven personalized learning has been shown to support meaningful learning and long-term retention of concepts.

Beyond cognitive outcomes, students' attitudes toward Physics play a crucial role in determining their learning behaviour, persistence, and future interest in science-related careers. Negative attitudes toward Physics have been linked to poor performance and high attrition rates in science subjects. Research indicates that innovative, interactive, and learner-centred instructional strategies enhance students' attitudes toward Physics and science in general (Osborne, Simon, & Collins, 2003). AI-driven personalized learning, by offering engaging and supportive learning experiences, has been reported to increase students' motivation and positive disposition toward science subjects (Zhai et al., 2021).

Despite the growing body of international research on AI-driven personalized learning, empirical studies examining its effectiveness in Nigerian secondary school Physics classrooms remain limited. In particular, there is a scarcity of evidence on how AI-driven personalized learning affects students' achievement, retention, and attitudes toward Physics in Abak Local Government Area of Akwa Ibom State. This study therefore seeks to investigate the effect of Artificial Intelligence–Driven Personalized Learning on secondary school students' achievement, retention, and attitudes toward Physics in Abak Local Government Area, Nigeria.

Statement of the Problem

Despite continuous curriculum reforms and teacher training programmes, students' achievement in Physics in secondary schools in Abak Local Government Area remains unsatisfactory. Traditional teaching methods dominate classroom practice, often failing to address individual learning differences among students. Consequently, many students develop poor retention of Physics concepts and negative attitudes toward the subject. While AI-driven personalized learning has shown promise in improving learning outcomes in developed countries, its effectiveness in Nigerian secondary school Physics classrooms is largely unexplored. This study therefore examines whether the integration of AI-driven personalized learning can improve students' achievement, retention, and attitudes toward Physics in Abak Local Government Area.

Purpose of the Study

The main purpose of this study was to determine the effect of Artificial Intelligence–Driven Personalized Learning on secondary school students' achievement, retention, and attitudes toward Physics in Abak Local Government Area.

Specifically, the study sought to:

1. To determine the effect of AI-driven personalized learning on students' achievement in Physics in Abak Local Government Area.

2. To examine the effect of AI-driven personalized learning on students' retention of Physics concepts in Abak Local Government Area.

3. To investigate the influence of AI-driven personalized learning on students' attitudes toward Physics in Abak Local Government Area.

Research Questions

1. What difference exists in the mean achievement scores of students taught Physics using AI-driven personalized learning and those taught using the conventional method?

2. What difference exists in the mean retention scores of students taught Physics using AI-driven personalized learning and those taught using the conventional method?

3. What difference exists in the mean attitude scores of students taught Physics using AI-driven personalized learning and those taught using the conventional method?

Research Hypotheses

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

H_{01}: There is no significant difference in the achievement of students taught Physics using AI-driven personalized learning and those taught using the conventional method.

H_{02}: There is no significant difference in the retention of students taught Physics using AI-driven personalized learning and those taught using the conventional method.

H_{03}: There is no significant difference in the attitudes of students taught Physics using AI-driven personalized learning and those taught using the conventional method.

Methods

The study adopted a quasi-experimental pretest–posttest non-equivalent control group design. The study was conducted in Abak Local Government Area of Akwa Ibom State, Nigeria. The population comprised all SSS II Physics students in public secondary schools in Abak Local Government Area. A sample of 120 SSS II Physics students from two public secondary schools was selected using purposive sampling. Intact classes were randomly assigned to experimental and control groups. Three instruments were used: Physics Achievement Test (PAT) – 30 multiple-choice items, Physics Retention Test (PRT) – reshuffled version of PAT administered after two weeks and Students' Attitude toward Physics Questionnaire (SAPQ) – 20-item Likert scale. The instruments were validated by experts in Physics Education and Measurement and Evaluation. Reliability coefficients obtained were 0.82 (PAT), 0.78 (PRT), and 0.86 (SAPQ).

Both groups were given a pretest. The experimental group was taught selected Physics topics using AI-driven personalized learning tools that provided adaptive content, quizzes, and feedback, while the control group was taught using the conventional lecture method. The treatment lasted six weeks, after which a posttest was administered. A retention test was conducted two weeks later. Mean and standard deviation were used to answer research questions, while ANCOVA was used to test hypotheses using pretest scores as covariates.

Results

Research Question 1

Table 1: Mean Achievement Scores of Students Taught Using AI-Driven Personalized Learning and Conventional Method

Group	N	Mean	SD
AI-Driven Personalized Learning	60	68.45	7.32
Conventional Method	60	54.18	8.10

Table 1 shows that students in the AI-driven personalized learning group obtained a higher mean achievement score ($X = 68.45$, SD = 7.32) than those in the conventional method group ($X = 54.18$, SD = 8.10). This indicates that students exposed to AI-driven personalized learning performed better in Physics than their counterparts taught using the traditional lecture method. The lower standard deviation recorded by the experimental group further suggests that students' performance was more consistent under the AI-driven personalized learning approach.

Research Question 2

Table 2: Mean Retention Scores of Students Taught Using AI-Driven Personalized Learning and Conventional Method

Group	N	Mean	SD
AI-Driven Personalized Learning	60	65.72	6.85
Conventional Method	60	50.64	7.94

Table 2 reveals that students taught Physics using AI-driven personalized learning had a higher mean retention score ($X = 65.72$, SD = 6.85) compared with those taught using the conventional method ($X = 50.64$, SD = 7.94). This result suggests that AI-driven personalized learning enhanced students' ability to retain Physics concepts over time. The relatively lower standard deviation for the experimental group indicates improved uniformity in retention among students exposed to the AI-based instructional approach.

Research Question 3

Table 3: Mean Attitude Scores of Students Taught Using AI-Driven Personalized Learning and Conventional Method

Group	N	Mean	SD
AI-Driven Personalized Learning	60	3.84	0.46
Conventional Method	60	2.91	0.52

Table 3 indicates that students exposed to AI-driven personalized learning recorded a higher mean attitude score toward Physics ($X = 3.84$, SD = 0.46) than those taught using the conventional lecture method ($X = 2.91$, SD = 0.52). This implies that the AI-driven personalized learning approach positively influenced students' attitudes toward Physics. The smaller standard deviation for the experimental group suggests greater consistency in positive attitudes among students taught with AI-supported personalized learning.

Hypotheses Testing

Table 4: ANCOVA Summary for Achievement

Source	F	Sig.
Method	24.63	0.000

Table 4 shows that there was a statistically significant effect of instructional method on students' achievement in Physics after controlling for pretest scores, as indicated by the obtained F-value of 24.63 at $p < 0.05$. This result implies that the difference observed in students' achievement was attributable to the instructional method employed. Consequently, the null hypothesis that there is no significant difference in the achievement of students taught using AI-driven personalized learning and those taught using the conventional method was rejected.

Table 5: ANCOVA Summary for Retention

Source	F	Sig.
Method	21.18	0.000

Table 5 reveals a statistically significant effect of instructional method on students' retention of Physics concepts when pretest scores were controlled, with an F-value of 21.18 at $p < 0.05$. This indicates that AI-driven personalized learning had a significant influence on students' retention of Physics concepts. Therefore, the null hypothesis stating that there is no significant difference in retention between students taught using AI-driven personalized learning and those taught using the conventional method was rejected.

Table 6: ANCOVA Summary for Attitude

Source	F	Sig.
Method	19.45	0.000

Table 6 indicates that instructional method had a statistically significant effect on students' attitudes toward Physics after adjusting for pretest scores, as evidenced by the F-value of 19.45 at $p < 0.05$. This suggests that the observed difference in students' attitudes was due to the instructional approach used. Hence, the null hypothesis that there is no significant difference in the attitudes of students taught using AI-driven personalized learning and those taught using the conventional method was rejected.

Discussion of Findings

The findings of this study revealed that students taught Physics using Artificial Intelligence–Driven Personalized Learning achieved significantly higher scores than those taught using the conventional lecture method. This result indicates that AI-driven personalized learning is more effective in enhancing students' academic achievement in Physics. The observed improvement may be attributed to the adaptive nature of AI-based learning environments, which provide individualized learning pathways, immediate feedback, and opportunities for continuous practice based on learners' needs.

This finding is consistent with previous studies which reported that personalized and technology-enhanced instructional approaches significantly improve students' achievement in science

subjects. Kulik and Fletcher (2016) found that intelligent tutoring systems produced substantial learning gains compared to traditional instruction. Similarly, Pane et al. (2017) reported that personalized learning approaches resulted in improved academic outcomes due to increased learner engagement and self-regulated learning. The present finding also aligns with the work of Utibe, Uboh, and Inyang (2022), who demonstrated that individualized and cooperative learning strategies significantly enhanced secondary school students' achievement in Physics. Although their study did not employ AI, both studies underscore the effectiveness of instructional approaches that respond to learners' individual differences.

The results further showed that students exposed to AI-driven personalized learning demonstrated significantly better retention of Physics concepts than those taught using the conventional method. This suggests that personalized learning environments promote meaningful learning and long-term retention of scientific concepts. AI-driven systems often reinforce learning through adaptive quizzes, repeated practice, and targeted feedback, which strengthen memory consolidation and conceptual understanding.

This finding supports earlier research which reported that intelligent learning systems enhance students' retention and transfer of learning. Holmes, Bialik, and Fadel (2019) noted that AI-supported learning environments facilitate deeper understanding by scaffolding instruction based on learners' progress. Kulik (2013) similarly observed that computer-based and intelligent tutoring systems significantly improve retention compared to traditional instruction. The present result also complements the findings of Utibe et al. (2022), which emphasized that individualized instructional approaches foster deeper learning and better retention in Physics. The study revealed that students taught using AI-driven personalized learning developed more positive attitudes toward Physics than those taught using the conventional lecture method. This may be attributed to increased learner autonomy, interactive learning experiences, and reduced anxiety associated with difficult Physics concepts. Positive attitudes are essential for sustained interest and success in Physics and other science-related fields.

This result corroborates the findings of Osborne, Simon, and Collins (2003), who reported that positive learning experiences and student-centred instruction significantly enhance students' attitudes toward science. It also aligns with the findings of Zhai et al. (2021), who observed that AI-supported learning environments increase students' engagement and motivation in STEM subjects. Furthermore, Utibe et al. (2022) reported that learner-centred instructional strategies promote positive attitudes toward Physics by actively involving students in the learning process. Collectively, these findings suggest that AI-driven personalized learning positively influences both the cognitive and affective domains of learning.

Lastly, the findings of this study provide empirical support for the integration of AI-driven personalized learning in secondary school Physics instruction, particularly in contexts where students' achievement, retention, and attitudes remain a concern.

Conclusion

This study examined the effect of Artificial Intelligence–Driven Personalized Learning on secondary school students' achievement, retention, and attitudes toward Physics in Abak Local Government Area of Akwa Ibom State, Nigeria. The findings provide compelling empirical evidence that AI-driven personalized learning significantly enhances students' academic achievement, promotes long-term retention of Physics concepts, and fosters more positive attitudes toward the subject when compared with the conventional lecture method.

The improved learning outcomes observed among students exposed to AI-driven personalized learning highlight the effectiveness of adaptive and learner-centred instructional approaches in addressing individual differences in learning pace, ability, and prior knowledge. By providing tailored instructional content, immediate feedback, and adaptive assessment, AI-driven personalized learning supports meaningful learning and sustained engagement in Physics. Beyond cognitive gains, the positive shift in students' attitudes underscores the potential of AI-based instructional strategies to reduce learning anxiety and increase motivation toward Physics.

Overall, the study demonstrates that Artificial Intelligence–Driven Personalized Learning represents a viable and effective pedagogical innovation for improving Physics education in Nigerian secondary schools. Its adoption can contribute significantly to addressing persistent challenges of poor achievement, weak retention, and negative attitudes toward Physics, particularly in contexts with diverse learner needs and limited instructional resources.

Recommendations

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

1. Integration into Classroom Practice

Physics teachers should incorporate AI-driven personalized learning tools into classroom instruction to complement traditional teaching methods and address individual learning differences among students.

2. Teacher Training and Professional Development

Teacher education institutions and professional development programmes should include training on the pedagogical use of Artificial Intelligence and personalized learning systems to equip teachers with the skills required for effective implementation.

3. Provision of Infrastructure and Support

Government and school administrators should provide adequate ICT infrastructure, including reliable internet access and digital devices, to support the integration of AI-based learning tools in secondary schools.

4. Curriculum and Policy Alignment

Curriculum planners and policymakers should revise the Physics curriculum to accommodate AI-driven personalized learning approaches as part of innovative instructional strategies aligned with global best practices in science education.

5. Further Research

Future studies should extend this research to other science subjects, educational levels, and geographical locations. Researchers are also encouraged to investigate the long-term effects of AI-driven personalized learning on students' higher-

order thinking skills, self-regulated learning, and career aspirations in STEM fields.

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