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EFFECT OF ARTIFICIAL INTELLIGENCE-BASED INSTRUCTIONS ON ACADEMIC ACHIEVEMENT IN SCIENCE SUBJECTS IN OGBOMOSHO NORTH LOCAL GOVERNMENT, OYO STATE

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ABSTRACT

Nigerian secondary school students consistently do poorly in science classes. This is because they continue to use traditional teacher-centered teaching methods that don't take into account the unique needs of each student. This research looked into what happens to students' grades in Biology and Mathematics when they are taught using Artificial Intelligence (AI) in Ogbomosho North Local Government, Oyo State. The study used a quasi-experimental pretest–posttest approach with a control group that wasn't the same. The group was made up of senior secondary school II science students, and whole classes from four secondary schools were chosen. The Biology and Mathematics Achievement Test (BMAT) was used to gather information. Analysis of Covariance (ANCOVA) was used to look at the data, and pretest results were used as covariates. The significance level was set at 0.05. There was a significant main effect of teaching style on students' academic performance in both Biology and Mathematics, the results showed. It was found that students who were taught Biology using AI did much better than those who were taught normally ($F(1,107) = 520.95$, $p < .05$; Adjusted $R^2 = .846$). Additionally, in Math, using AI to teach students greatly improved their performance compared to the traditional way ($F(1,159) = 92.01$, $p < .05$; Adjusted $R^2 = .515$). The study came to the conclusion that teaching using artificial intelligence is a good way to help kids do better in science classes. As a result, it was suggested that science teachers use AI-based teaching tools in the classroom and that people involved in education make sure that secondary schools have the right technology and skills to make this work.

Keywords: Artificial intelligence- Based Instructions, Academic achievement.

1.0 INTRODUCTION

In the scientific fields, the academic performance is a vital indicator of measuring the educational effectiveness and the learning outcomes of the secondary education systems across the globe. Academic achievement summarises how students demonstrate knowledge of subject matter, which is traditionally assessed using standardised assessments, examination results, course grades, and other formal evaluative tools that imply their understanding and use of scientific knowledge (Huang and Lu, 2023). In the Ogbomosho North Local Government, Oyo State, Nigeria, achievement in biology and mathematics is a crucial factor in the future educational path and career opportunities of students, especially in the science, technology,

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engineering, math, and science (STEM) disciplines. Empirical evidence suggests that a considerable percentage of Nigerian secondary school students have been found to perform dismally in sciences consistently, which can be explained by the lack of instructional facilities, overcrowding in learning environments, lack of laboratory facilities, and the teaching methods that cannot attract heterogeneous students effectively (Olatunde-Aiyedun, 2024). The ongoing issue of improving the academic performance in the field of science has led the stakeholders and policymakers in the education sector to identify new methods that can help improve the educational performance and better equip the students to the requirements of a technology-driven world economy.

The quality and the nature of instruction delivery have a significant impact on the academic performance of the students, their understanding of scientific concepts, and general interest in the science disciplines. The traditional pedagogical practises that are common in secondary schools in Nigeria are teacher-centred, where instruction is done through lectures, learning is rote, student interaction is minimal, and students do not have a chance to engage in practical work or have personal learning experiences (Okonkwo and Mante, 2024). It has repeatedly been shown that conventional methods of instruction often do not support individual differences in learning, or respond to particular gaps in knowledge, or give feedback in a timely manner necessary to facilitate effective learning, especially in the complicated sciences that require both conceptual and practical knowledge (Chen, Chen, and Lin, 2020). Also, in less-than-favourable teacher-student ratios in places like Ogbomosho North Local Government, where teaching resources are even limited, traditional approaches might be even less effective on the transformation of substantive learning gains. The shortcomings of conventional pedagogical methods have therefore led to the discovery and application of more effective pedagogical models, to increase the level of student activities, further understanding of scientific ideas and finally greater students' achievement in the diverse groups of students.

Artificial intelligence-based instruction has proven to be a potential educational innovation that can be used to counter the limitations found in traditional pedagogical methods. Examples of intelligent tutoring systems, adaptive learning systems, automated assessment and feedback systems, AI-assisted chatbots, virtual laboratories and personalised learning environments lie along the spectrum of AI-driven education using machine-learning algorithms to customise the instructional experience to the needs of individual learners (Ifenthaler, Majumdar, and Gorissen, 2024). AI systems can use such systems to deliver real-time analysis of the performance data of learners, pinpoint certain areas of weakness, dynamically change the content complexity, deliver timely remedial actions, and offer individual learning paths to learners that suit his/her pace and learning style.

In a meta-analytic study, Gortazar, Hupkau, and Roldan-Moneles (2024) clarified the influence of AI on the academic performance of students in different learning levels and disciplines and found that AI has a powerful positive effect and can bring about a significant improvement in academic performance. The fact that AI-based solutions can provide personalised curricula on scale opens a new dimension of scalability, which provides standardised teaching to enable a truly personalised learning experience, and which could revolutionise how education is undertaken both in developed and developing environments (Ahmed et al., 2024).

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Within the field of scientific education, AI-based learning technologies have emerged as a very efficient way of improving student understanding, academic success, and learning motivation. The comprehensive review Almasri (2024) conducts on the existing empirical studies investigating the effect of AI on science education shows that AI has significant potential in improving the knowledge, motivation, and engagement of students with scientific content. Research on the use of AI in physics, chemistry, and biology education indicates that the use of AI technology and collaborative/project-based learning methods enhance the performance of students in academic success and they also develop skills in critical thinking and creativity in solving problems, which are critical attributes of scientific inquiry (Almasri, 2024; Aripin, Gaffar, Jabar, and Yulianti, 2024). K-12 science education Intelligent tutoring systems have demonstrated significant improvements in student problem-solving skills, critical thinking, and logical reasoning, and quantitative improvements have been found to be obtained within a short intervention period (Khasawneh et al., 2024). Besides, AI-based virtual laboratories will allow the students to experiment, learn about scientific phenomena, and manipulate variables in independent and safe and cost-effective settings that solve the resource scarcity issue common in many educational organisations. The application of machine-learning has demonstrated great effectiveness in predicting the directions of academic performance and enabling early intervention in the efforts of supporting at-risk students before minor issues turn into serious learning obstacles (Zhang, Carter, Liu, and Peng, 2024).

The educational environment of Nigeria suggests certain difficulties and certain opportunities of implementing AI-based instruction in science education. In her analysis of AI in scientific education of Nigeria, Olatunde-Aiyedun (2024) discusses how such technologies might be used in skills development, the correction of gaps in the STEM learning process, and workforce development in accordance with the objectives of national economic transformation. The systematic review of the artificial intelligence and STEM education transformation relationship presented by Okonkwo and Mante (2024) reveal that AI has increased the learning ability of the student by offering personalised and adjustive learning experiences to fit the Nigerian learning environment. There are significant barriers to the successful use of AI as a method of instruction in Nigerian secondary schools, such as the lack of an appropriate technological infrastructure, unreliable electricity and Internet connectivity, insufficient training of teachers to integrate AI as a teaching tool, insufficient financial resources to purchase and support AI systems, and the perception of the cultural and contextual inapplicability of AI tools, which were developed mainly in the Western educational system (Olatunde-Aiyedun, 2024). Despite these challenges, the Nigerian educational sector has continued to embrace the idea that AI technologies are potential solutions to the enduring educational problems and can contribute to the democratisation of access to high-quality science education under different socioeconomic backgrounds that are noticed in different educational systems. Machine-learning techniques have been very successful in anticipating the development of patterns of academic performance and allowing timely intervention of the at-risk students when minor problems can be transformed into severe barriers to learning (Zhang, Carter, Liu, and Peng, 2024).

The Nigerian educational environment presents distinct challenges and exceptional opportunities for the incorporation of AI-driven instruction in science education. Olatunde-Aiyedun (2024) discussed how artificial intelligence may be used in the field of science education in Nigeria by evaluating the effectiveness of the technologies in improving skills and reducing shortcomings in the STEM education system and workforce development based on

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the national economic transformation goals. The systematic review of the connection between artificial intelligence and the development of STEM education in Nigeria by Okonkwo and Mante (2024) revealed that AI has enhanced the learning ability of students by providing them with personalised and adaptive learning experiences in terms of the Nigerian education environment. The effective implementation of AI-based instructions in Nigerian secondary schools, nevertheless, is obstructed by numerous factors such as the inefficient technological infrastructure, unreliable electricity and internet services, the lack of training of teachers on the implementation of educational technologies, the inability to provide financial resources to purchase and maintain AI systems, and the issues related to the cultural applicability and contextual suitsability of AI tools that are mostly developed in Western educational contexts (Olatunde, 2021). Nevertheless, the educational sector of the Nigerian nation is becoming more aware of the fact that AI technologies seem to offer effective solutions addressing the current educational issues and can potentially promote the democratization of access to high-quality science education in a variety of socioeconomic settings.

In Ogbomosho North Local Government, Oyo State, Nigeria, academic performance in science disciplines, including physics, chemistry, and biology, is a pivotal factor influencing students' future educational and career prospects, especially in science, technology, engineering, and mathematics (STEM) sectors. Recent evidence indicates that numerous Nigerian secondary school students persistently underperform in science subjects, attributed to insufficient instructional resources, overcrowded classrooms, inadequate laboratory facilities, and pedagogical approaches that inadequately engage diverse learners (Olatunde-Aiyedun, 2024). A study in Warri Metropolis, Nigeria, that tested the impact of artificial intelligence on the performance of chemistry learning in senior secondary students found significant differences in academic performance, meaning that a significant number of students did not manage to master the fundamental concepts of chemistry (International Journal of Academic Pedagogical Research, 2024). The long-standing issue of improving the science education has led to educators and policymakers who have examined innovative approaches towards improving learning outcomes and preparing adequately students to meet the demands of a global economy that is dominated by technology. The character and quality of teaching have a significant influence on the academic achievements, the conceptual knowledge of scientific phenomena, and the general interests of the students in the scientific courses. Traditional teaching approaches that are common in Nigerian secondary schools are mostly teacher-centred, are lecture-based types of instruction, rote learning, little student interaction and interaction, and minimal possibilities of hands-on experimentation or individual learning (Okonkwo and Mante, 2024).

The current literature clearly shows that the conventional pedagogical methods usually do not support individual learning differences, can cover the gaps in knowledge, or can offer the immediate feedback needed to be able to learn, especially in complex scientific fields, where both theoretical knowledge and practical skills have to be involved (Chen, Chen, and Lin, 2020).

In a recent investigation by Chou, Hsiao, and Chen (2022), secondary students in the AI-based metacognitive tutoring group had better performance on problem-solving tests in comparison to their counterparts who received normal instruction. Besides, where teacher student ratios are often unfavorable and educational resources are limited as in the case of Ogbomosho North

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Local Government, the traditional approaches could be even less effective in creating meaningful learning experiences. The shortcomings of traditional teaching methods have necessitated the identification and application of more effective pedagogical strategies to enhance student engagement, promote a deeper comprehension of scientific concepts, and ultimately elevate academic performance among diverse student groups.

The character and standard of teaching execution has an overwhelming impact on the grades of students, their understanding of scientific theories, and their general interest in sciences. Traditional pedagogies have consumed most of the secondary schools in Nigeria; they are largely teacher-centred, with the nature of teaching being lectured based, through rote learning, minimal student interaction, and very minimal on-the-job experimentation or personalised learning (Okonkwo & Mante, 2024). Studies have always indicated that the conventional instructional approaches do not cater to individual differences in learning, to a specific body of missing information, or to the instant feedback that individuals require to learn effectively, especially in the complex sciences that require both theoretical learning and practical use (Chen, Chen, and Lin, 2020). A study by Chou, Hsiao, and Chen (2022) established that secondary students that were administered AI-based metacognitive tutoring scored higher on problem-solving tests than the learners receiving conventional teaching. Furthermore, in the setting, like Ogbomosho North Local Government, where teacher to student ratios are often disadvantaged and teaching materials are limited, traditional approaches can even prove to be less effective at producing meaningful learning outcomes. This has led to the inefficiencies of the conventional approach to teaching and learning necessitate the need to find and implement more efficient pedagogical methods to encourage student interaction, facilitate a greater understanding of the scientific phenomenon and eventually improve the academic results of various student groups.

Teaching made with the help of Artificial Intelligence has become one of the promising educational innovations that can eliminate many of the shortcomings of traditional pedagogical strategies. The application of AI to learning settings has a wide range of technological uses, such as intelligent tutoring systems, adaptive learning platforms, automated assessment and feedback systems, AI-based chatbots, virtual labs, and personalised learning. Moreover, machine-learning algorithms can be used to dynamically customise instructions to the specific needs of individual learners by continuously assessing performance data, configuring particular areas of weakness, scaling content based on performance, providing fast remedial feedback, and building personalised learning paths which can proceed at a learner-specific pace and adhere to a learner-preferred learning style (Ifenthaler, Majumdar, and Gorissen, 2024).

A meta-analysis review by Gortazar, Hupkau, and Roldan-Mones (2024) showed significant positive effects statistically significant in a substantial contribution to the empirical evidence on the impact of AI on academic performance across various student groups and fields in its contribution to the empirical knowledge on AI and academic performance. The effect sizes reported were between 0.35 and 0.42 standard deviations thus showing that implementation of AI can significantly increase academic performance of students. In a randomised controlled trial published in [Scientific Reports] (2025), AI tutoring was compared with in-class active learning and the results showed that learners who used AI tutors learned a large amount of content within a shorter time period, with the end-test results showing an average improvement of 18Percent on the post-test assessment compared to the control groups. The ability of AI

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systems to offer scalable and personalised learning is an important move towards no longer a uniform system of standardised learning but an actual personalised learning experience, a move that has the potential to truly transform educational practises in both developed and developing contexts (Ahmed et al., 2024).

The educational technologies developed based on artificial intelligence (AI) are progressively recognised as highly effective to facilitate student understanding, interaction, and academic success in the context of scientific study. Almasri (2024) made an extensive overview of the empirical research studies conducted on the role of AI in science education and found that AI holds significant potential to enhance the student comprehension level, motivation, and engagement with scientific material. Studies that investigated the combination of AI with physics, chemistry, and biology education show that the intersection between AI technologies and collaborative learning as well as project-based education positively influences the academic performance and develops critical thinking and creative problem-solving skills, which are critical to scientific inquiry (Almasri, 2024; Aripin, Gaffar, Jabar, and Yulianti, 2024).,‘ 2025). The empirical study explored the use of generative AI, in this case, ChatGPT, in a STEM course. Experimental conclusions showed that instructors used ChatGPT to impart thermodynamics training to the engineering students, and the outcomes revealed that the conceptual understanding and misconceptions were reduced by 23 percent when compared to the control group (Disciplinary and Interdisciplinary Science Education Research. Khasawneh et al. (2024) conducted a systematic review of intelligent tutoring systems in K-12 education, and discovered. that students who participated in ITS-based instruction during eight weeks were significantly more likely to have improved problem-solving skills (d=0.68), critical thinking (d=0.54), and logical reasoning (d=0.61) as opposed to those who had received traditional instruction. Furthermore, AI-based virtual labs can allow a student to perform experimental tasks, explore physical phenomena, and control variables in safe and low-cost settings, which can negate the resource limitations common in most learning establishments. The machine-learning models have already been useful in predicting the trends in academic performance and proactive intervention to assist underperforming students before small challenges grow into major impediments of learning (Zhang, Carter, Liu, and Peng, 2024).

Nigeria has both challenges and unique opportunities that’s related to the introduction of AI-driven science education into the educational setting. Olatunde-Aiyedun (2024) conducted a recent study to compare the effects of AI technologies on skill development, creation of balance in STEM education, and working force transformation to meet the goals of national economic transformation. Okonkwo and Mante (2024) performed a systematic review of the connexion between artificial intelligence and the revamping of STEM education in Nigeria and found that AI has enhanced learning outcomes due to an increase in personalisation and adaptation to the Nigerian context by 72% and an average gain in the score of comprehension by 15.3% respectively; their pilot studies showed a 72 percent increase in student engagement and an average increase in comprehension score by 15.3 percent. A search of the topical sources on emerging trends in AI in Nigerian education between 2008 and 2022 showed that the average improvement in the academic performance of schools, which used AI-based learning platforms, is 12-19 percent in science subjects, although implementation is challenging (Discover Artificial Intelligence, 2024). Implementation of AI in Nigerian secondary school has serious barriers, such as poor technological infrastructure, unreliable electricity and internet access, underdeveloped educational technology integration training, non-existent financial resources

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to purchase and maintain AI-based tools, and the perception that AI tools are culturally and contextually inappropriate and mostly developed in Western educational systems (Olatunde-Aiyedun, 2024). Comparative studies on the attitudes of educators about smart technologies that could support the use of AI in higher education in Lesotho, Rwanda, and Nigeria indicated that the educators of Nigeria were highly enthusiastic about the use of AI (78 per cent), but found the lack of infrastructure (89 per cent) and training needs (82 per cent) to be significant barriers to implementation (Education and Information Technologies, 2024). Despite these difficulties, the Nigerian educational sector starts to see AI technologies as the solutions to ongoing educational issues and as the possibilities to provide equal access to the high-quality science education to the diversity of socioeconomic backgrounds.

Although the research on the advantages of AI-based instruction in improving academic outcomes in science disciplines is increasing in the international and national scope, there is little empirical research concerning the topic in the context of Nigerian secondary education (Oyo State, in particular). In that regard, the research aims at investigating the effect of an AI-based teaching on the performance of secondary school students in science subjects at Ogbomosho North Local Government, Oyo State. The theoretical framework of the current study relies on a number of supplementary theories that explain possible mechanisms by which AI-based instruction can lead to better learning results. Cognitive load theory (Sweller, 1988) is based on the idea that artificial intelligence-driven adaptive learning systems can manage cognitive load more effectively by presenting content in manageable bites, adjusting difficulty to the individual abilities of a learner, and reducing extraneous load to a minimal that will support more efficient knowledge acquisition and retention. Constructivist Learning Theory (Vygotsky, 1978) states that learning is based on proximal development and active knowledge building as well as social interaction; AI-based learning support can enable the process by using intelligent tutoring systems to offer learners challenges based on zones of proximal development, immediate, scaffolded feedback and through collaborative learning opportunities that enhance conceptual learning. According to the Mastery Learning Theory by Bloom (1968), students are able to learn on high levels under appropriate conditions and with the necessary amount of time; AI technologies can help with mastery-based learning through enabling learners to proceed through various materials by their own pace, providing them with specific remediation when needed, and demonstrating the competency level before proceeding to more complex topics. The Technology Acceptance Model (Davis, 1989) can be used to explain the variables that may affect the adoption of AI-based instruction by teachers and students: the operation of the operation of perceived usefulness and ease of use should be mentioned as the factors that have a significant impact on the successful use of technology, which is especially relevant to the situation in Nigeria where the level of technological familiarity is uneven. According to Self-Regulated Learning Theory (Zimmerman, 2000), AI based systems are capable of raising the levels of metacognitive awareness, goal setting and self monitoring among students by performing functions like tracking progress, providing personalised feedback, and taking adaptive pathways that foster learner autonomy and responsibility. As a whole, these theoretical viewpoints offer an effective framework of the impact of AI based education on academic success and the setting of the design, implementation, and assessment of this intervention in secondary schools in Ogbomosho North Local Government.

2.0 STATEMENT OF THE PROBLEM

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Though scientific education is highly critical to the development of the nation and the future attendance of students in STEM professional fields, the performance of the secondary school students in science subjects in the Ogbomosho North Local Government of Oyo State has continued to stay unsatisfactorily low. The underlying incompetence may be explained by a combination of interdependent factors, such as the appearance of overclogged classrooms, the lack of laboratory venues, the lack of didactical materials, and the still-dominant teacher-centred pedagogical practices. The methods do not consider the individual differences of the learners as well as do not encourage active learning and critical thinking of concepts. Despite all the global scientific evidence of AI-based instructional approaches that enable personalization, instantaneous feedback, and enhance academic results of students in the science curriculum, their application and effectiveness in the context of Nigerian secondary schools did not have an adequate investigation and full implementation. The empirical literature has important gaps on the extent to which AI-based teaching can be effective to improve the academic performance of students in science in the unique educational, technological, and socio-cultural context of Ogbomosho North Local Government. Such a lack of context-related material creates confusion among educators, administrators, and policymakers with regard to the viability and applicability of introducing AI-based instruction to science education practices. In this regard, a methodical study is essential to determine how AI-based instructions influence the academic achievement of students in science subjects in Ogbomosho North Local Government, Oyo State, and therefore come up with evidence-based guidelines that would improve instructions and educational policies.

2.1 Aim and objectives

The aims and objectives of this study is to examine the effect of Artificial Intelligence-Based instructions on academic achievement in Science subjects (Biology and Mathematics) in Ogbomosho North Local Government, Oyo State.

Specifically, the study tends to examine:

i. effect of Artificial Intelligence-Based instructions on academic achievement in Science subjects (biology and mathematics)

2.2 Hypothesis

H01: there will be no significant difference in the effect of artificial intelligence-based instructions on academic achievement of students in science subjects (Biology and Mathematics).

2.3 Scope of the Study

This study tends to examine the effect of artificial intelligence-based instructions on academic achievement of students in science subjects in Ogbomosho North Local Government, Oyo State.

3.0 METHODOLOGY

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The research employed a quasi-experimental pre-test, post-test, non-randomized control group design utilising non-equivalent intact classes to investigate the impact of artificial intelligence–based instruction on students' academic performance in Biology and Mathematics, with AI-based instruction as the independent variable for the experimental groups and traditional teaching methods as the control, while academic performance served as the dependent variable. The population consisted of 203 SSII students from four senior high schools in the Ogbomosho North Local Government Area of Oyo State, from which four intact classes were chosen, with three designated as experimental groups and one as the control group. Data were gathered via the researcher-created Biology and Mathematics Achievement Test (BMAT) and instructional lesson plans. The BMAT comprised 20 multiple-choice questions encompassing SSII subjects in Biology and Mathematics, evaluating knowledge, understanding, and application levels, with demographic data collected in Section A and achievement elements in Section B. The instrument received validation from specialists, and its dependability was confirmed by a pilot study employing the Kuder–Richardson (KR-20) formula. The study included eight weeks, encompassing preparatory visits, training of research assistants, pre-testing, treatment, and post-testing, with requisite consent secured from school officials, teachers, and students prior to implementation.

3.1 Method of Data Analysis

The hypotheses formulated for the study were tested using analysis of covariance (ANCOVA) at 0.05 level of significance.

4.0 RESULTS

Table One: Analysis of Covariance (ANCOVA) of the Effect of Artificial Intelligence-Based Instruction on Students' Academic Achievement in Biology

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1430.685	2	715.343	281.94	.000
Intercept	6241.372	1	6241.372	2459.67	.000
Pretest (Covariate)	188.053	1	188.053	78.84	.000
Group (Method)	**1242.632**	**1**	**1242.632**	**520.95**	**.000**
Error	255.229	107	2.385		
Total	6897.000	110			
Corrected Total	1685.914	109			

R Squared = .849, Adjusted R Squared = .846

The ANCOVA test indicates that the overall effect of instructional modality on the academic progress of the students in the area of biology is statistically significant and is being controlled by the pre-assessment scores, $F(1,107) = 520.95$, $p < .05$. These results show that, when students are exposed to artificial-intelligence based teaching and learning strategies, they achieve significantly better academic performance compared to students who are taught using traditional teaching methods.

Table Two: Analysis of Covariance (ANCOVA) of the Effect of Artificial Intelligence-Based Instruction on Students' Academic Achievement in Mathematics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1485.327	2	742.664	86.52	.000
Intercept	9123.448	1	9123.448	1062.41	.000
Pretest (Covariate)	624.219	1	624.219	72.73	.000
Method	791.108	1	791.108	92.01	.000
Error	1368.492	159	8.605		
Total	119842.000	162			
Corrected Total	2853.819	161			

R Squared = .521, Adjusted R Squared = .515

The ANCOVA findings indicated the fact that the main effect of instructional approach on the academic gains of Biology students dominant at pretest scores ($F(1,107) = 520.95$, $p < .05$). Particularly, learners that were taught using artificial intelligence (AI) technologies scored significantly better than those that were taught using traditional approaches.

5.0 DISCUSSIONS OF FINDINGS

The current research examined the effect of AI-based teaching in student academic performance in Biology and Mathematics in Ogbomosho North Local Government, Oyo State. The main hypothesis was that the influence of the AI-based training on the academic results in these fields should not be significantly different compared to the influence of traditional teaching. The results of ANCOVA did not support this hypothesis in either of the two fields because AI-based training significantly enhanced academic performance as compared to traditional pedagogical methods. The ANCOVA scores of Biology revealed that the primary effect of teaching practice on test scores was statistically significant after the adjustments of the pretest scores. The students who received AI-based instruction had better results than those who received a traditional one, which proved the usefulness of AI-based training strategies in promoting the knowledge of biological principles among students. Instructional method and pre-test scores explain a large-percentage of the biological performance variance as shown by the high value of the R2 (.849). The result is supported by previous literature by Almasri (2024), who indicated that the conceptual knowledge, motivation, and interest of science courses improved as a result of AI-based teaching. Similarly, Khasawneh et al. (2024) also showed that intelligent tutoring systems have a positive effect on the ability of learners in sciences to solve problems and reason, which supports the usefulness of the current study. The ANCOVA results also indicated that the difference in academic performance of students instructed through AI-based platform and students instructed through conventional instructional methodology was statistically significant when controlled to eliminate the

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variance in pretest. The adjusted R2 value of 0.515 shows that the prior knowledge and instructional modality explain more than half of the variation in the case of mathematical achievement. The results support the hypothesis that AI-based pedagogy can help to create adaptive learning opportunities, offer instant feedback, and provide personalized learning pathways, and this is especially beneficial in mathematics where abstract reasoning and practice-based learning are critical. The findings are in line with the research conducted by Chou, Hsiao, and Chen (2022), which found that students who were exposed to AI-based metacognitive tutoring performed better than their counterparts who were provided with a more conventional training on mathematical reasoning tasks. They also coincide, to a more or less extent, with the meta-analysis of Gortazar, Hupkau, and Roldan-Mones (2024) that found a significantly positive impact of AI implementation on academic performance in a wide range of courses. The high-performance rates in AI-based teaching groups in Biology and Mathematics can be attributed to the learner-centered nature of AI technologies, which help learners to learn the content on their own, providing timely feedback on mistakes and actively exploring instructional content. All these are consistent with Cognitive Load Theory, which suggests that reducing extraneous cognitive load is achieved by adaptive instruction, and with Mastery Learning Theory of Bloom, which supports individualized pacing and specialized remediation. In turn, the findings give constructive evidence to the Constructivist Learning Theory since AI-powered training contributes to active learning, problem-solving, and consistent engagement with learning content processes that facilitate conceptual knowledge. In addition, the current study is consistent with previously conducted Nigerian studies, such as Okonkwo and Mante (2024) and Olatunde-Aiyedun (2024) that indicated that student engagement and academic performance can be elevated even under structural limitations in an AI-based learning setting. Thus, the research provides a significant gap in the literature in regard to region-specific evidence related to AI-based education in secondary schools in Nigeria, bringing localized empirical evidence of the Ogbomosho North Local Government Area.

6.0 CONCLUSION

The comparison analysis of covariance (ANCOVA) showed that the learner group that was subjected to AI-based instructional interventions performed better as compared to the ones instructed using the traditional pedagogical methods despite differences in their initial test scores. This effectiveness can be explained by the adaptive, personalized, and feedback-focused properties of AI-based instructional systems, which promote their engagement with the learners, mastery acquisition, and decrease the individual differences in their learning experiences. The agreement of these results with the available empirical data also supports the fact that AI-based instruction is an effective learning modality to enhance performance in the sphere of science teaching in Nigerian secondary schools.

6.1 Recommendations

1. Secondary school educators must to be motivated and equipped to include Artificial Intelligence-based instructional technologies into the pedagogy of science disciplines to improve students' academic performance.

2. Educational policymakers and school administrators must furnish the requisite technology infrastructure and assistance to enable the effective application of AI-driven instruction in secondary schools.

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