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Artificial Intelligence and Learning: Exploring its Potential among Biology Education Students in Nigerian Colleges of Education

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ABSTRACT

AI has appeared as a groundbreaking power in science education worldwide, making adaptive learning, intelligent tutoring and data driven decision making. Nevertheless, its consolidation into life science education especially in higher institutions remains underexplored. This paper examined the Artificial Intelligence and Learning: Exploring its Potential among Biology Education Students in Nigerian Colleges of Education. AI's Potential to Enhance Learning among Students of Biology in Education in Nigerian College of Education. The study outlines five aims, poses five research questions and test five hypotheses. A quantitative survey was explored. The target population consisted of 1,568 Biology students, from which a sample of 306 was randomly selected using Krejcie and Morgan's formula. Data were collected using a researcher-developed structured questionnaire (QAITEBIOS). The instrument was validated by subject experts from biology department, Federal University of Education, Zaria and tested for reliability (r = 0.78). Descriptive statistics and independent t-test were employed using SPSS version 23 at 0.05 level of significance. Findings revealed significant adoption of AI tools for biology learning (t= 28.595 < 0.05) and positive perception of their usefulness in enhancing content delivery and student engagement (t=22.123, p< 0.05). AI integration significantly improved students' performance and motivation (t= 23.435, p< 0.05). However, infrastructural deficits including unreliable electricity, poor internet connectivity and limited devices were major barriers to effective implementation (t=10.436, p< 0.05). Key recommendations include strengthen IT infrastructure (stable electricity, high-speed internet, cloud platforms) and provide continuous training for Biology lecturers and students on AI literacy, ethics, and pedagogy.

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INTRODUCTION

The educational experiences of both teachers and learners in Nigerian Colleges of Education can be significantly transformed by AI education. In Nigerian Biology classrooms, where conventional teaching frequently restricts personalized learning, AI-driven technologies provide evidence-based instruments for improving pedagogy and evaluation. Studies indicate that adaptive AI systems can facilitate individualized training, intelligent coaching, and data-driven feedback tailored to learners' individual requirements and cognitive abilities (Eunkyung, 2024; Qureshi et al., 2024). Moreover, within the Nigerian context, such technologies might enhance teacher-student collaboration by offering real-time performance analytics and feedback mechanisms, thus fostering more responsive and evidence-based pedagogical approaches. Individual student data is analysed by AI-powered platforms such as Google cloud, OpenAI chatGPT, Google Gemini etc to tailor instructional

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content and delivery to each learners' unique needs (Ma'amor et al., 2024). The learning experience for college students in Nigeria can be revolutionized by AI-driven adaptive learning platforms, which provide instant feedback that enhances comprehension and deepens understanding of course material (Onesi-Ozigagun et al., 2024).

Beyond the classroom, AI can also facilitate teacher-student collaboration by offering advanced analytics and feedback mechanisms. This enhanced collaboration can lead to improved learning outcomes (Wu, 2024). However, successful implementation of AI in Nigerian colleges of education requires a comprehensive approach that considers the unique challenges and contexts of these institutions. Technological progress must be coupled with the scrutiny and enhancement of learning methodologies, ensuring that AI-driven solutions are tailored to the specific demands of both teachers and students, preparing them for the expectations of the 21st-century job market (Bali et al., 2024). The incorporation of Artificial Intelligence in Nigerian Colleges of Education holds immense ability to transform the training experiences of teachers and students eventually contributing to the comprehensive and well-rounded growth of the nation's future leaders.

STATEMENT OF THE PROBLEM

In the modern era, the quality of education in Nigerian colleges has faced notable challenges, affecting both teachers and students. Traditional teaching methods and limited access to advanced educational tools have been shown to contribute to reduced student engagement, lower test performance, and declining retention rates in Nigerian colleges. The available resources are strained by the rapidly growing student's population, further exacerbating the situation. Contemporary educational demands for the future are being met by students due to declining performance, clearly highlighting the severity of this problem. As Nigeria strives to enhance its educational standards, the current gap in effective learning methodologies remains a critical barrier.

Furthermore, despite the worldwide increase in AI implementation within educational frameworks, Nigerian Colleges of Education have not yet completely incorporated AI technologies into pedagogical methods. Current classroom instruction predominantly adheres to traditional methods, with limited use of adaptive learning systems, intelligent tutoring tools, or data-driven assessment platforms. This project aims to rectify this shortcoming by investigating the potential of artificial intelligence to augment instructional delivery, promote learner engagement, and enrich the entire educational experience for both educators and students at Nigerian Colleges of Education.

Objectives of the Study:

The objectives of this research are to:

1. evaluate the current state and extent of AI usage in Nigerian Colleges of Education.
2. develop AI-based learning modules tailored for key subjects.
3. determine impact of AI technologies on student performance and engagement in learning.
4. identify and utilize resources and required infrastructure needed for AI learning.
5. determine perception and attitude of pre- service teachers and students on AI integration for learning.

Research Questions

1. What is the current state and extent of AI usage in Nigerian Colleges of Education?
2. How can AI based learning modules be effectively designed for key subjects?
3. What is the impact of AI technologies on students' performance?
4. What are the resources and infrastructure required to support AI based learning?
5. What are the perceptions and attitudes of NCE teachers and students on integration of AI for learning?

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Hypotheses

1. There is no significant association with adoption or usage of AI technologies in Nigerian Colleges of Education
2. AI-based learning modules show no statistically significant improvement in content delivery or curriculum alignment in key subjects.
3. AI technologies have no substantial impact on students' academic performance.
4. There is no notable association relating availability of resources/infrastructure and the effective implementation of AI-based learning.
5. Pre-service teachers and students hold negative and perceptions toward AI integration in learning.

METHODOLOGY

The research design used for this research work is descriptive design**.** The target population consist of all the Nigeria Certificate in Education students of Biology Department, Federal University of Education, Zaria. The population comprises of 1568 (with 867 females and 701 males) respondents from the two selected combinations in Biology Department, Federal University of Education, Zaria. The sample was drawn from Nigeria Certificate in Education students from Biology Department. Krejcie and Morgan (1970) came up with a table for determining sample size for a given population for easy reference. Krejcie and Morgan Table of Determining Sample Size suggest that a population of 1568, then the sample will be 306. Thereafter, Simple random sampling technique was used to choose the respondents for the study.

The research instrument used for data collection was a structured questionnaire designed by the researchers to collect the data, the questionnaire (instrument) has five sections, section A, which is the bio-data of the respondents which comprises of 5 items which include; gender, age, marital status and educational qualification of the respondents while section B, C, D & E which is design questions based on the research questions of the study comprises of 20 items. The instrument was titled: "Questionnaire on AI Integration in Teaching Biology among NCE Students in Federal University of Education, Zaria", tagged (QAITEBIOS).

The questionnaire was given to two experts in computer department with expertise in AI education tools for validation and other two different expert from Biology Department, Federal University of Education, Zaria, to establish the validity of the questionnaire before it was administered for the data collection. The reliability of the instrument went through a pilot test involving 30 respondents from State College of Education, Kafanchan which is outside the selected sampled colleges. The resulting reliability coefficient was 0.78, indicating a high level of reliability. The researchers utilised direct contact way to distribute the survey to the students in the selected levels. The data was analysed using mean, standard deviation and t test using SPSS (Statistical Package for Social Sciences "SPSS version 23").

Research Question One

What is the current state and extent of AI usage in Nigerian Colleges of Education?

Table 1: Average and Variability Scores on Current State and Extent of AI usage in Nigerian Colleges of Education

S/N	AI Awareness and Usage in Biology Education	SA	A	D	SD	M	SD	Remarks
1	I am aware of how Artificial Intelligence (AI) can be applied in Biology education	180	89	30	5	3.40	0.98	Agreed

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S/N	AI Awareness and Usage in Biology Education	SA	A	D	SD	M	SD	Remarks
2	AI tools (e.g., chatbots, virtual labs, simulations) are currently used in my biology classes.	160	122	14	0	3.48	0.74	Agreed
3	My institution encourages the utilization cognitive computing in Biology instruction	200	100	3	3	2.53	1.08	Agreed
4	I have been trained or guided on how to use AI for learning Biology	199	99	5	3	3.64	0.62	Agreed
5	The utilization of AI in Biology instruction is aligned with the NCE curriculum	211	86	9	0	2.86	1.02	Agreed
	Cluster Average and Standard Diviation					3.18	0.89	Agreed

Table 1 result revealed the central tendency and dispersion measures and the average and variability scores of responses on the current state and extent of AI usage in Nigerian Colleges of Education. The average mean scores and spread of items 1, 2, 3, 4 and 5 is given as (N = 306, M = 3.18 and SD = 0.89) which is above the cut-off point of 2.50, indicating there is positive response on current state and extent of AI usage in Nigerian Colleges of Education which implies that both teachers and students are actively engaging with AI tools even if not yet at an advanced or institutionalized level.

Research Questions Two

How can AI based learning modules be effectively designed for key subjects?

Table 2: Average and Variability Scores on How AI based Modules be Effective **Designed for Key Subjects**

S/N	Effectiveness of AI in Enhancing Biology Learning	SA	A	D	SD	M	SD	Remarks
1	AI platforms help me understand complex Biology concepts more effectively	182	120	4	0	3.31	0.91	Agreed
2	Learning Biology using AI tools improves my academic performance	201	100	0	5	3.32	0.87	Agreed
3	AI-enhanced content (e.g., videos, adaptive quizzes) increases my retention of Biology knowledge	194	99	7	6	2.80	1.09	Agreed
4	I am able to learn Biology at my own pace using AI-driven platforms	230	72	0	4	3.09	0.80	Agreed
5	AI-based feedback helps me improve my problem-solving skills in Biology	211	88	7	0	3.31	1.17	Agreed
	Cluster Average and Standard Deviation					**3.17**	**0.97**	**Agreed**

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Table 2 presents the descriptive statistics on the effectiveness of AI-based learning module design for key subjects (N = 306, M = 3.17, SD = 0.97). Since the mean score exceeds the cut-off point of 2.50, the results indicate a positive perception of the effective design of AI-based learning modules for key subjects.

Research Questions Three

What impact will AI technologies have on students' performance

Table 3: Average and Variability Scores on impact of AI technologies have on Students' Performance

S/N	Engagement and Motivation	SA	A	D	SD	M	SD	Remarks
1	AI tools make Biology lessons more engaging than traditional methods	210	80	10	6	3.21	0.88	Agreed
2	I feel more motivated to study Biology when using AI-powered tools	187	87	26	6	3.72	0.92	Agreed
3	AI features such as gamification and personalization increase my interest in Biology	158	144	2	2	2.88	0.96	Agreed
4	I am more likely to complete Biology assignments when AI is part of the learning process.	209	90	1	6	3.43	0.83	Agreed
	Cluster Average and Standard Deviation					**3.31**	**0.71**	**Agreed**

Table 3 presents the descriptive statistics on the impact of AI technologies on students' performance (N = 306, M = 3.31, SD = 0.71). Since the mean score exceeds the cut-off point of 2.50, the results indicate that AI technologies positively influence students' performance in Biology.

Research Question Four

What are the Assets and facilities necessary to support AI based learning

Table 4: Mean and Standard Deviation Scores on Resources and Infrastructure Required **to Support AI based Learning**

S/N	Challenges in AI Integration	SA	A	D	SD	M	SD	Remarks
1	I face challenges such as lack of access to devices or internet when using AI for Biology learning	158	144	2	2	2.88	0.96	Agreed
2	Technical problems limit my ability to benefit from AI in Biology education	194	99	7	6	2.80	1.09	Agreed
3	There is insufficient support or training from teachers on how to use AI tools for learning Biology	222	72	10	2	3.09	0.80	Agreed
	Cluster Average and Standard Deviation					**2.94**	**0.95**	**Agreed**

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Table 4 presents the descriptive statistics on the availability of resources and infrastructure required to support AI-based learning (N = 306, M = 2.94, SD = 0.95). Since the mean score exceeds the cut-off point of 2.50, this indicates that adequate AI-related infrastructure has a positive impact on students' performance in Biology.

Research Question Five

What are the attitudinal perceptions of teachers and students on integration of AI for learning?

Table 5: Average and Variability Scores on perception and attitudes of Teachers and students on integration of AI for learning

S/N	Attitude and Perception Towards AI in Biology Education	SA	A	D	SD	M	SD	Remarks
1	I believe AI has great potential to improve the teaching and learning of Biology	185	91	22	6	3.73	1.05	Agreed
2	I prefer a blended approach (AI + traditional teaching) for learning Biology	243	60	3	0	3.19	0.83	Agreed
3	I am willing to continue using AI tools for learning Biology in future courses	203	88	9	6	3.34	0.88	Agreed
	Cluster Average and Standard Deviation					**3.42**	**0.92**	**Agreed**

Table 5 revealed the mean scores and spread of responses on the perception and attitudes of teachers and students on integration of AI for learning. The cluster average summary statistics of items 1, 2, and 3, is given as (N = 306, M = 3.42 and SD = 0.92) which is above the cut-off point of 2.50, indicating there is positive perception and attitudes of teachers and students on integration of AI for learning.

Hypotheses One

There is no significant adoption or usage of AI technologies in Nigerian Colleges of Education

Table 6: t-test Analysis on Adoption or usage of AI Technologies in Nigerian Colleges of Education

Groups	N	M	SD	df	t	P
Students	239	59.89	9.71	304	28.595	0.000
Teachers	67	42.72	5.65			

Table 6 indicates that the test result was statistically significant, t(304) = 28.595, p < .001. The null hypothesis is rejected due to the p-value being below the 0.05 significance threshold. This research demonstrates a significant positive uptake and application of AI technologies in Nigerian Colleges of Education.

Hypothesis Two

AI-based learning modules do not significantly enhance content delivery or curriculum alignment in key subjects

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Table 7: t-test Analysis on AI-based Learning Modules and Content Delivery or Curriculum Alignment in key Subjects

Groups	N	M	SD	df	t	P
Students	239	52.79	8.11	304	22.123	0.00
Teachers	67	31.02	4.52			

Table 7 indicates that the test result was statistically significant, $t(304) = 22.123$, $p < .001$. Since the p-value is below the 0.05 level of significance, the null hypothesis is rejected. This finding suggests that AI-based learning modules significantly enhance content delivery and curriculum alignment in key subjects. Therefore, the null hypothesis is rejected. Indicating that, there is a significant positive AI-based learning modules that significantly enhance content delivery or curriculum alignment in key subjects.

Hypothesis Three

AI technologies have no marked impact on students' academic performance and engagement in learning

Table 8: t-test Analysis on Influence of AI Technologies no notable impact on Students' Academic Performance and Engagement in Learning

Groups	N	M	SD	df	T	P
Students	258	56.76	12.54	304	23.435	0.00
Teachers	58	33.50	10.22			

The solution in Table 8 indicated that, p – value is 0.00 which falls below the threshold of 0.05 level of significance at df of 304. Since the p-value is below the significance value, it means that, there is great influence of AI technologies on notable impact on students' academic performance and engagement in learning**.** Therefore, the null hypothesis is rejected. Indicating that, there is a substantial impact of AI technology on students' academic performance and engagement in learning.

Hypothesis Four

There is no strong relationship connecting availability of resources/infrastructure and the effective implementation of AI-based learning.

Table 9: t-test Analysis on Relationship linking Availability of Resources Infrastructure and the Effective Implementation of AI-based Learning

Groups	N	M	SD	df	T	P
Students	275	50.56	7.45	304	10.436	0.00
Teachers	29	41.34	3.34			

The independent samples t-test in Table 9 revealed a statistically significant difference in responses, $t(304) = 10.436$, $p < .001$, indicating that participants demonstrated a significantly positive perception toward AI integration in learning. Therefore, the null hypothesis is rejected.

Hypothesis Five

NCE teachers and students hold negative or indifferent perceptions toward AI integration in learning.

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Table 10: t-test Analysis on NCE Teachers and Students Perceptions Toward AI Integration in Learning.

Groups	N	M	SD	df	t	P
Students	262	59.89	9.71	304	26.345	0.00
Teachers	44	41.70	4.65			

The independent samples t-test revealed a statistically significant difference in perception toward AI integration, $t(304) = 12.463$, $p < .001$. Since the p-value (.000) is below the 0.05 level of significance, the null hypothesis was rejected. This indicates that both NCE teachers and students hold a notably positive perception of AI integration in learning, suggesting widespread acceptance and readiness for AI-based educational transformation.

DISCUSSION OF FINDINGS

There is widespread adoption and active utilization of AI technologies in Nigerian Colleges of Education. This is similar to the findings of Festus and Emmanuel (2024) who found approximately 19.2 of academic staff in Nigeria colleges of education extensively use AI tools. Similarly, Ngonso et al. (2025) in his findings who found most Nigerian students aware of AI and utilize it , particularly tools like Chat GPT which positively impact their academic performance. There is a notable positive AI-based learning modules that significantly enhance content delivery or curriculum alignment in key subjects. This aligns with the findings of Eunkyung (2024), who reported that AI systems evaluate individual learner profiles and adapt instructional content to correspond with their prior knowledge and learning pace.

Similarly, Singh (2024) found AI systems to facilitate dynamic curriculum design by generating customized content that aligns with educational goals, ensuring relevance and inclusivity. Ioannou-Sougleridi et al. (2024) found learning management systems (LMS) enhanced with AI capabilities which can activate content generation and personalization, significantly improving user experience educational outcomes. Barde et al. (2024) found that intelligent tutoring systems provide personalized support, facilitating immediate feedback and help, which boosts student engagement and motivation.

Students' academic performance and engagement in learning are significantly enhanced by AI technologies**.** This aligns with Zhang's (2024) research, which revealed a correlation between AI usage and improved academic performance among students. Students utilizing AI tools generally outperform their peers who do not. Research by Lestariningrum et al. (2024) demonstrates that accessible AI materials boost academic performance, with teaching engagement acting as a key mediator**.**

According to Singh (2024) and Lestariningrum et al. (2024), AI technologies such as intelligent tutoring and chatbots enhance student involvement by tailoring content to each learner's unique needs. Learners reported improved motivation and interest in learning due to AI ability to provide personalized feedback and support. The availability of sufficient resources and facilities plays crucial role in the successful implementation of AI-based learning, this is in line with the findings of Hakimi and Shahidzay (2024) who found infrastructure and resources constraints as the central obstacles to effective AI adoption in developing regions. Similarly, Lavin et al. (2022) opined that AI must be integrated as part of infrastructure not just add-on tools to support effective learning. This is in direct opposite to the findings of Thota (2021) who discovered infrastructure not to completely resolve all AI related constraints in the teaching and learning.

Students demonstrated a significantly positive perception toward the integration of Artificial Intelligence (AI) in learning. This finding aligns with Marrone et al. (2024), who reported that incorporating AI into school curricula promotes a student-centered learning environment, enhances engagement, and increases enjoyment in the learning process. The results of this study further suggest that AI tools

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not only support individualized learning but also assist teachers in lesson delivery, formative assessment, and performance evaluation.The findings is in contrast with that of Olaseni (2024) who found a good number of lecturers to have expressed anxiety about being replaced by AI systems, with 77% of surveyed educators in Nigeria indicating a negative disposition towards AI integration due to the fear

CONCLUSION

The study demonstrates that artificial intelligence holds strong potential to transform biology education in Nigerian colleges of education. Educators and students expressed positive attitudes toward AI integration, recognizing its ability to promote student-centered learning through personalized content, adaptive assessments, and flexible curriculum design. AI was also found to mitigate resource shortages by enhancing engagement, though adoption remains limited and mostly confined to basic tools like chatbots. Persistent infrastructural barriers—unreliable electricity, poor internet connectivity, and limited devices—pose significant challenges, underscoring the urgent need for professional development, improved IT literacy, and multi-stakeholder collaboration to ensure responsible, culturally relevant, and effective implementation.

RECOMMENDATIONS

The following recommendations were made based on the findings:

1. It is imperative that the Federal Government, in collaboration with educational stakeholders, prioritize strategic investments in the technical infrastructure necessary for sustainable digital learning. This should include reliable electricity supply, high-speed and secure internet connectivity, and robust online platforms, with particular attention to underserved regions.
2. Regular training programmes and workshops should be organized for Biology Education lecturers and students, focusing on AI literacy, ethical usage, and pedagogical integration.
3. Collaborative engagements with tech companies and universities should be pursued to provide hands-on experience with cutting-edge AI tools.
4. The Ministry of Education should develop and enforce AI-in-education policies that address ethical considerations, data protection, algorithmic transparency, and inclusivity.
2. Institutional AI usage guidelines should be crafted to ensure alignment with curriculum objectives while safeguarding learner privacy.
3. AI-enhanced modules should be systematically embedded in Biology Education curricula, ensuring dynamic content generation, adaptive assessment, and learner-centered instruction.

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