Harnessing AI for Inclusive and Innovative Learning and Research among Pre-Service Biology Teachers' in Kwara State Colleges of Education

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Abstract

The study examined the integration of Artificial Intelligence (AI) tools in promoting inclusive and innovative learning and research among pre-service biology teachers in Colleges of Education in Kwara State, Nigeria. Using a descriptive survey design, data were collected from 73 randomly selected pre-service biology teachers across three institutions. A structured questionnaire explored the extent of AI integration, utilization for research and pedagogical innovation, and perceptions, competencies, and concerns regarding AI adoption. Findings revealed a generally high level of AI integration in teacher training, with most respondents affirming the use of AI for lesson planning, supporting diverse learners, and enhancing research output. AI tools such as ChatGPT, Grammarly, and Quillbot were widely used for academic purposes, while confidence in AI's potential to make teaching more engaging was strong. However, concerns about ethical issues, potential teacher replacement, and the need for further training were notable. The study concludes that while AI adoption in pre-service biology education is promising, sustained institutional support, targeted AI literacy programs, and robust policy frameworks are essential for maximizing its potential.

Keywords: Artificial intelligence, Inclusive and Innovation research, Pre-service Biology Teacher, Colleges of Education

Introduction

In today's knowledge driven world, the demands on education systems are evolving rapidly, necessitating innovative teaching practices and inclusive learning environments that can cater to diverse learner needs. The development of many countries is greatly influenced by science. According to Bradford and Hamer (2022) defined science as a systematic and logical method used to determine the mechanisms by which everything in the universe functions. It can also be defined as a collection of information gathered and combined through methods for figuring out the nature of everything in the universe. The branches of science include pure science and applied science. Pure science includes chemistry, physics, and Biology. Biology as a subject is concerned with the study of life and living organisms, including their structure, function, growth, evolution, distribution, and taxonomy. Bios means life and logo means study of science (Lim & Dutfield, 2022). Biology can be best taught when technology is introduced into teaching.

Technology however has shifted educational practices from conventional methods to more engaging, and digitalized formats. The integration of technology into various sectors is not merely a trend but a necessity for progress (Luckin et al., 2024). In education, technology can facilitates enhanced learning experiences and research capabilities. In broader contexts, it drives efficiency,

addresses societal challenges, and fosters innovative (Olusola & Ogunleye, 2020). This technological gap not only hinders innovation in instructional practice but also undermines equity in learning, especially when pre-service teachers are not trained to support learners with diverse needs using available technological resources (Luckin et al., 2016). Advancement in technology has generated fresh opportunities for renovating instructional methodologies. Generative AI applications, such as ChatGPT and DALL-E, have developed as great tools in education. These applications facilitate the development of lesson plans, enables the creation of interactive simulations of depicting biological processes, and offer personalized feedback to learners, thereby supporting more effective teaching and learning experiences (Jimba-Na'Allah et al., 2024).

Artificial intelligence (AI), once a futuristic concept, is now reshaping various sectors including education through its capacity to personalize learning, streamline instructional delivery, and enhance data informed decision making (Holmes et al., 2019). Within this transformation, the education of teacher particularly pre-service teachers plays a crucial role in preparing future educators for classrooms increasingly influenced by intelligent technologies.

Pre-services teacher education serves as the foundation for equipping future educators with both content knowledge and pedagogical skills. However, many teacher preparation programs, particularly in low and middle income countries, remain largely traditional in their structure, lacking integration of 21st century tools such as AI (Lumanlan, 2025). Pre-service teachers increasingly view artificial intelligence (AI) applications as valuable tools for enhancing teaching and learning experiences. In the submission of Alejandro et al., (2024), opined AI technologies facilitate personalized learning, data driven instruction, and adaptive feedback, allowing educators to better address students learning gaps. However, the successful adoption of these tools depends on various psychological and contextual factors. AI-driven tools such as intelligent tutoring systems, content generation platforms such as ChatGPT, Gemini, and Perplexity among others, and adaptive learning environments have the potential to foster inclusive pedagogy and enrich academic research among teacher trainees (Xie et al., 2022)

Despite growing awareness of AI's capabilities, there is limited empirical research focusing on how pre-service teachers interact with these tools, what competencies they develop, and how institutional structures either enable or constrain AI adoption. Concerns about ethics, digital inequality, lack of infrastructure, and insufficient faculty modeling continue to pose serious challenges (Owolarafe et al., 2024). At the same time, global case studies from countries such as Ghana, Germany, and the Philippines suggest that structured AI training, cultural responsiveness, and policy alignment can significantly enhance AI acceptance and efficacy in teacher education (Lacuna, 2025; Zhang et al., 2023; Nyaaba, 2025)

Statement of the Problem

The traditional model of teacher education in many developing countries including Nigeria, is struggling to keep pace with the demands of 21st century learning, particularly in terms of inclusivity and innovation. Pre-service biology teachers' training often lacks exposure to emerging technologies such as Artificial Intelligence (AI), which have the potential to transform both learning experiences and research capacity. Despite the global surge in AI adoption across sectors,

many pre-service biology teachers remain ill equipped to use AI tools effectively for lesson planning, differentiated instruction, and academic inquiry. Furthermore, concerns regarding infrastructure, digital literacy, ethical considerations, and institutional readiness persist. These challenges pose significant risks to educational equity and the professional preparedness of future teachers. Therefore, there is an urgent need to explore how AI can be systematically harnessed to support inclusive and innovative practices in pre-service biology teacher education, and to access the perceptions, competencies, and limitations influencing its adoption.

Purpose of the Study

The general purpose of this study is to investigate the integration of Artificial Intelligence (AI) tools in promoting inclusive and innovative learning and research among pre-service biology teachers in Colleges of Education in Kwara State, Nigeria. Specifically, the study seeks to:

1. Determine the extent to which AI tools are being integrated into pre-service biology teacher education to support inclusive learning practices.
2. Examine how pre-service biology teachers utilize AI technologies to enhance their research skills and pedagogical innovation.
3. Assess the perceptions, competencies, and concerns of pre-service biology teachers regarding the use of AI tools in their training programs.

Research Questions

1. To what extent are Artificial Intelligence (AI) tools being integrated into pre-service biology teacher education to support inclusive learning practices in Colleges of Education in Kwara State?
2. How do pre-service biology teachers in Kwara State Colleges of Education utilize AI technologies to enhance their research skills and promote innovation in teaching practice?
3. What are the perceptions, competencies, and concerns of pre-service biology teachers regarding the use of AI tools in their teacher education programs in Kwara State?

Literature Review

Concept of Artificial Intelligence (AI) in Teacher Education

Artificial intelligence (AI) is a technology tools from adaptive tutoring engines to Large Language Models (LLMs) and Generative AI, are entering classrooms and teacher education programs at pace. According to Ogunode and Ukozor (2023) defined AI as the machines that have the capacity to carry out tasks that are meant to be performed by human intelligence. Artificial

Intelligence (AI) refers to the simulation of human intelligence processes by machines, particularly computer systems, to perform tasks such as learning, reasoning, problem-solving, and decision-making (Xiaoyang, 2023). In education, AI is increasingly being adopted to enhance teaching and learning processes, streamline administrative functions, and promote innovation in instructional delivery (UNESCO, 2019). Teacher education, on the other hand, encompasses the structured training, professional preparation, and continuous development of individuals to become qualified educators, particularly at primary, secondary, and tertiary levels (Usman & Okoye, 2024).

The relationship between AI and teacher education lies in AI's capacity to transform the management of teacher training programmes through tools that improve curriculum design, automate administrative tasks such as student enrolment and record-keeping, and provide adaptive learning platforms that cater to diverse learning needs (Usman & Okoye, 2024). In Nigeria, particularly in Federal Colleges of Education, the integration of AI remains limited, with most institutions still relying on conventional ICT tools rather than fully embracing AI-driven systems due to infrastructural, technical, and policy constraints (Usman & Okoye, 2024). However, the potential of AI to improve teacher education is substantial, as it can support innovative teaching practices, data-driven decision-making, and personalized professional development, thereby aligning teacher preparation with 21st-century educational demands.

Biology Education in Colleges of Education

The Colleges of Education are teachers' training institutions created to cater for students who are potential teachers, and they are awarded National Certificate in Education (NCE), after the completion of their three years training. The National Commission for Colleges of Education (NCCE) are the body in charge of all the affairs of Colleges of Education. One of the several programs suggested by NCCE is the Biology Education. Students admitted into biology education must take biology and one other related subject in order to complete two teaching subjects. Biology education is an important component of students' worldwide and knowledge base, giving them the groundwork to continue their education or work in the sphere of life science (Umeohana, T. E., 2024).

In the submission of Bizimana, Mutangana, and Mwesigye, (2021), opined biology as the study of life and pure science. The subject is very important to the development of society most especially for undergraduates pursuing their careers in pharmacy, medicine, Nursing and those proposing to be a biology teacher. Biology education refers to biology instruction that teaches individuals about their bodies, identities, and how those bodies work. Therefore, biology education is the application of educational concepts to biology instruction. The ability to affect or transmit biology knowledge to students requires mastery of teaching and training skills (Farounbi, 2014).

Nigerian Colleges of Education's NCE Biology programs aim to produce teachers who can: view biology as a process of inquiry into the living world; critically evaluate the actions of living

things in their surroundings; demonstrate practical skills in handling scientific apparatus; teach biology with excellence and professionalism; promote positive views towards biological science and scientific endeavors in society and incorporate positive scientific attitudes and values throughout; apply course knowledge to new fields of study and to situations that arise in daily life; make a successful career in biology teaching, and obtain the credentials required to enrol in a B. SC(ED) degree program.

The minimum standards for teacher educators in colleges of education outline the basic minimum that educators must know and be able to do, as well as the minimal attitudes that educators should have toward their profession, if they wish to continue and grow in their careers (Nigeria's Minimum Education Certificate Standard, 2013). Courses such as Cell Biology, basic biological principles, bacteria, viruses, and lower plants; ecology; diversity of invertebrates; animal histology; research methods and biometry; Biology practical IV; diversity of chordates; population education; plant pathology; animal histology; evolution; laboratory management; applied biology; introductory parasitology; genetics; biology practical V; plant physiology; vertebrates; anatomy and physiology.

These courses, along with other second teaching subjects like Chemistry, Physics, Mathematics, Integrated Science, Computer Science, Physical and Health Education, and General Studies; Education Courses, including Teaching Practice (TP); and other activities, are accredited and recognized by the National Commission for Colleges of Education (NCCE). Successful completion of these activities results in the awarding of a Nigeria Certificate in Education.

Integration of Artificial Intelligence for Inclusive and Innovative Pedagogy in Pre-service Biology Teacher Education

It is highly important to introduce Artificial Intelligence (AI) into teachers' education right from the classroom during normal class activities. The pre-services teachers' should be taught different AI tools and how to use them; they should be encouraged to use them wisely and ethically than abusing it. AI has come to stay. The integration of AI into pedagogy will assist the pre-service teachers in a long way with their academics. The integration of AI into teacher education has emerged as a transformative pathway for promoting inclusive and innovative pedagogy in science classroom. Empirical evidence shows that pre-service science teachers' intention to use generative AI in inquiry-based teaching is significantly influenced by perceived usefulness, perceived ease of use, and AI literacy (Ramnarian et al., 2024). According to Ramnarian et al. (2024) reported that structured exposure to AI tools enhances pre-services teachers' technological confidence and pedagogical experimentation in science education. These findings underscore the importance of embedding AI competencies within biology teacher preparation programmes to foster innovative instructional practices.

In the submission of Adigun et al. (2025); Kalnina et al. (2024) described readiness and preparedness for AI integration remain critical in teacher education programs. Their findings indicate that although many pre-service teachers demonstrate positive attitudes towards AI, significant gaps persist in practical application skills and ethical awareness. Adigun et al. (2024)

opined that in the context of Nigerian, institutional support, digital infrastructure, and formal AI training significantly predict behavioral intention to adopt AI for inclusive classrooms. These findings highlight that effective AI integration in Colleges of education requires not only technological access but also systematic institutional readiness and curriculum redesign.

Methodology

The study adopts a descriptive research design of survey type. Survey method of descriptive study was chosen because of the type of data collected through quantitative approach. The descriptive survey method was adopted to obtain information from Pre-service biology teachers. The population of the study consists of all pre-service teachers in state owned colleges of education in Kwara State. The target populations are pre-service biology teachers in the three colleges of education in Kwara State. The total of 73 pre-service biology teachers was randomly selected from all the three colleges of education for the study. A structured questionnaire was employed as the primary data collection via Google form which was sent to each lecture in the department of biology of the three colleges of education. The questionnaire was designed with multiple sections each corresponding to specific research questions related to the study.

RESULTS AND DISCUSSION

Presentation of results

SECTION A: Presentation of Demographic Data

Table 1:

Information on gender

Gender	Frequency	Percentage (%)
Male	31	41.9%
Female	42	58.1%
Total	**73**	**100%**

Table one shows that out of the 73 participants in the study, 31 were male, making up 41.9% of the total, while 42 were female, representing 58.1%. This indicates that female

participants slightly outnumbered male participants, suggesting a modest gender imbalance in favor of females in the sample.

Table 2:

Information on the level of respondents

Level	Frequency	Percentage (%)
100	10	13.7%
200	21	28.8%
300	42	57.5%
Total	**73**	**100%**

Table two shows that among the 73 respondents, 10 were in 100 level (13.7%), 21 were in 200 level (28.8%), and 42 were in 300 level (57.5%). This indicates that the majority of participants were in 300 level, followed by those in 200 level, with 100 level students making up the smallest group in the sample.

Table 3:

Information on Institution

Institution	Frequency	Percentage (%)
College A	42	57.5%
College B	4	5.5%
College C	27	37.0%

Total	**73**	**100%**

Table three reveals that 42 respondents (57.5%) were from College A, making it the largest group in the study. College C followed with 27 respondents (37.0%), while College B had the smallest representation, with only 4 respondents (5.5%). This shows that more than half of the participants came from College A, while College B contributed very few respondents compared to the other institutions.

Research Questions 1: To what extent are Artificial Intelligence (AI) tools being integrated into pre-service biology teacher education to support inclusive learning practices in Colleges of Education in Kwara State?

Extent of AI tools integration into Pre-services Biology Education

S/N	**Extent of AI tools integration into Pre-services Biology Education**	**SA**	**A**	**D**	**SD**	**MEAN**
1.	AI tools are frequently used during my teacher training classes to support learning diversity.	29(39,2%)	40(54.1%)	03(4.1%)	01(1.4%)	1.67
2.	My institution provides access to AI-based platforms for inclusive lesson delivery.	19(25.7%)	37(50.0%)	15(20.0%)	02(2.7%)	2.00
3.	AI technologies are incorporated into our teaching methods courses	24(32.4%)	28(37.8%)	20(27.0%)	01(1.4%)	1.97

	for inclusive learning practices.					
4.	I am encouraged to use AI applications to address the needs of diverse learners.	31(41.9%)	36(48.6%)	05(6.8%)	1(1.4%)	1.67

Table four presents respondents' views on the extent of AI tools integration into pre-service biology education. For the first item, 39.2% strongly agreed and 54.1% agreed that AI tools are frequently used during teacher training classes to support learning diversity, while only a small proportion disagreed (4.1%) or strongly disagreed (1.4%). The low mean score of 1.67 indicates a high level of agreement. On the second item, 25.7% strongly agreed and 50.0% agreed that their institution provides access to AI-based platforms for inclusive lesson delivery, whereas 20.0% disagreed and 2.7% strongly disagreed. The mean score of 2.00 still reflects overall agreement, though slightly lower than in the first item. For the third items, 32.4% strongly agreed and 37.8% agreed that AI technologies are incorporated into teaching methods courses for inclusive learning practices, with 27.0% disagreeing and 1.4% strongly disagreeing. The mean score of 1.97 suggests general agreement, though with a noticeable portion expressing dissent.

Finally, regarding encouragement to use AI applications to address the needs of diverse learners, 41.9% strongly agreed and 48.6% agreed, while only 6.8% disagreed and 1.4% strongly disagreed. The mean score of 1.67 again shows strong consensus in favor of the statement. Overall, the responses indicate that most participants perceive AI tools as being actively integrated into their teacher training, especially in supporting diverse learners, though access to AI-based platforms appears slightly less consistent.

Research Question 2: How do pre-service biology teachers in Kwara State Colleges of Education utilize AI technologies to enhance their research skills and promote innovation in teaching practice?

S/N	**How do pre-service teachers utilize AI technologies to enhance their research skills and innovation in practice?**	**SA**	**A**	**D**	**SA**	**MEAN**
5.	I have used AI tools (e.g., ChatGPT, Grammarly, Quillbot) in conducting research assignments or projects.	31(41.9%)	35(47.3%)	7(9.5%)	0(0%)	1.67
6.	AI technologies have helped me generate innovative ideas for lesson planning and teaching strategies.	28(37.8%)	35(47.3%)	08(10.8%)	02(2.7%)	1.78
7.	I use AI tools to assist in structuring or analyzing academic papers.	19(25.7%)	43(58.1%)	10(13.7%)	01(1.4%)	1.90
8.	AI has improved the quality and creativity of my research output.	15(20.3%)	46(62.2%)	11(14.9%)	01(1.4%)	1.88
9.	AI platforms promote inquiry-based learning and problem-solving in my training.	31(38.3%)	31(38.3%)	13(16.0%)	06(7.4%)	1.97

Table five shows that most pre-service teachers reported actively using AI tools like ChatGPT, Grammarly, and Quillbot for their research projects, with about 42% strongly agreeing and 47% agreeing, and only a few not using them. A large number also said AI helps them come up with creative ideas for lesson planning and teaching strategies nearly 86% agreed in total, while

just a small fraction disagreed. More than 80% indicated they use AI to help structure or analyze academic papers, showing that AI is a common tool for organizing and improving their writing.

When it comes to the overall quality and creativity of their research, the majority (over 82%) felt that AI had a positive effect, with very few disagreeing. Finally, a good number (around 76%) agreed that AI platforms support inquiry-based learning and problem-solving in their training, though a small group did not share this view.

Research Question 3: What are the perceptions, competencies, and concerns of pre-service biology teachers regarding the use of AI tools in their teacher education programs in Kwara State?

S/N	**Perceptions, Competencies, and Concerns of Pre-service biology teachers in the use of AI**	**SA**	**A**	**D**	**SD**	**MEAN**
10.	I feel confident in using AI tools to support my learning and teaching activities.	16(21.6%)	54(73.0%)	03(4.1%)	0(0%)	1.77
11.	I believe AI can make teaching more engaging and effective for future classrooms.	20(27.0%)	40(54.1%)	13(17.6%)	0(0%)	1.92
12.	I worry about AI replacing the role of teachers in the future.	23(31.1%)	36(48.6%)	14(18.9%)	0(0%)	1.88
13.	I am aware of the ethical concerns involved in using AI for educational purposes.	14(18.9%)	53(71.6%)	04(5.4%)	02(2.7%)	1.90
14.	I need more training to use AI tools effectively in educational settings.	31(38.3%)	31(38.3%)	13(16.0%)	06(7.4%)	1.82

Table shows that most pre-service biology teachers feel confident in using AI tools to support their learning and teaching about 95% agreed or strongly agreed with a mean score of 1.77, showing high confidence levels overall. A large majority 81% believe that AI can make teaching more engaging and effective for future classrooms, though 18% of the respondents are less convinced. 80% of the respondents about expressed concern that AI might replace the role of teachers in the future, suggesting some anxiety about AI's impact on the profession. Awareness of ethical concerns is also high over 90% said they were aware of potential ethical issues in using AI for education indicating that most pre-service teachers understand the need to use AI responsibly. Lastly, about 77% said they need more training to use AI tools effectively, highlighting that while confidence and awareness are high, there is still a strong demand for skill development.

Discussion of findings

The findings demonstrate that AI tools are becoming an integral part of pre-service biology teacher education in Kwara State, particularly for supporting inclusive teaching and enhancing research productivity. High levels of agreement on the frequent use of AI in training indicate a growing acceptance of technology as a valuable educational asset. The widespread use of generative AI applications for research and lesson planning underscores their role in fostering creativity, efficiency, and adaptability among pre-service teachers. Nevertheless, the presence of ethical concerns and fears about AI replacing teachers highlight the importance of balanced integration that safeguards human facilitation in education. The expressed need for additional training suggests that institutional efforts must move beyond access to technology, focusing instead on structured capacity-building programs that empower future educators to harness AI effectively and responsibly.

Conclusion

This study concludes that AI is increasingly recognized as a valuable tool in pre-service biology education in Nigeria, with strong evidence of adoption for research, lesson planning, and inclusive teaching practices. Pre-service teachers are confident in using AI and acknowledge its potential to enhance teaching effectiveness, yet they also express legitimate concerns about ethics and teacher replacement. The readiness to embrace AI is evident, but successful integration into teacher education programmes will require deliberate institutional support, comprehensive training, and policy frameworks that ensure equitable access and ethical use.

Recommendations

Based on the findings of the study, the following were recommended:

1. Teacher training institutions should embed structured AI literacy modules into teaching methods courses, focusing on both technical skills and pedagogical applications.
2. Colleges of Education should organize regular practical workshops where pre-service teachers can experiment with AI tools for lesson planning, assessment, and research.
3. Institutions should invest in AI-enabled educational resources and ensure that all students, regardless of location or economic background, can access them.
4. Training should explicitly address ethical issues, data privacy, bias in AI systems, and strategies for maintaining the teacher's role as a facilitator of learning.
5. Policymakers should support Colleges of Education with the digital infrastructure needed for large-scale AI adoption, especially in underserved areas

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