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Generative Artificial Intelligence in Biology Education: Examining Secondary School Teachers' Awareness, Perception, and Utilization through the Technology Acceptance Model in Kaduna State, Nigeria

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Abstract

Generative Artificial Intelligence (GenAI) is increasingly recognized for its potential to improve lesson planning and delivery; however, its integration into secondary school Biology teaching remains underexplored in Nigeria. Guided by the Technology Acceptance Model (TAM), this study investigated Biology teachers' awareness, perception, and utilization of GenAI tools in lesson planning and instructional delivery in Kaduna State and examined the relationships among these variables. A descriptive survey design was employed involving a population of 287 Biology teachers, from which 169 were selected using a multistage sampling procedure. Data were collected using a 30-item researcher adapted questionnaire that was face and content validated by experts and yielded a Cronbach's alpha reliability coefficient of .897. Descriptive statistics and Pearson Product Moment Correlation were used for data analysis at the .05 significance level. The findings revealed low awareness (M = 2.20) and utilization (M = 1.83,), but a positive perception (M = 3.06). Significant positive relationships were found among the variables. These findings extend TAM by demonstrating that positive perceptions alone do not guarantee classroom utilization where awareness and institutional support are inadequate. The study recommends targeted professional development and improved institutional support to promote effective integration of GenAI into Biology teaching.

Keywords: generative artificial intelligence, awareness, perception, utilization, biology teachers, technology acceptance model

1 Introduction

Artificial Intelligence (AI) has emerged as one of the most transformative technologies of the twenty-first century, reshaping diverse sectors through intelligent automation, decision support, and content generation (Sarker, 2022). A major advancement is Generative Artificial Intelligence (GenAI), which can produce human-like text, images, audio, and other digital content to support knowledge creation and communication (Lund & Wang, 2023). In education, GenAI is transforming teaching by assisting lesson planning, instructional resource development, assessment design, personalized learning, and student engagement (OECD, 2023). Its relevance is particularly evident in Biology education, where visualization, scientific inquiry, and laboratory-based learning are essential (Bewersdorff et al., 2025). However, concerns relating to ethics, academic integrity, data privacy, algorithmic bias, and equitable access highlight the need for teachers who possess the knowledge and competence to integrate GenAI responsibly (Holmes et al., 2022).

Recognizing both the opportunities and risks associated with AI, international and national policy frameworks have emphasized its responsible adoption in education. UNESCO's Recommendation on the Ethics of Artificial Intelligence advocates ethical, transparent, and human-centred AI implementation while promoting educators' digital competencies (UNESCO, 2021). Similarly, Nigeria's National Artificial Intelligence Strategy identifies education as a priority sector for AI integration through digital literacy, innovation, research, and human capital development (Federal Ministry of Communications, Innovation and Digital Economy [FMCIDE], 2023). Achieving these goals depends largely on teachers, whose readiness is reflected in their awareness, perception, and utilization of GenAI tools. Awareness refers to teachers' knowledge of the existence, functions, and potential applications of an innovation and represents the first stage of technology adoption (Rogers, 2003). Perception encompasses teachers' beliefs about the usefulness, relevance, and ease of using technological tool in teaching (Ertmer et al., 2016), while utilization refers to its actual application in lesson planning, instructional material development, assessment, and classroom delivery. Although these constructs are theoretically related, their relationships are not always linear, as increased awareness does not necessarily translate into positive perceptions or sustained classroom utilization.

Existing empirical evidence presents similarly mixed findings regarding teachers' adoption of GenAI tools. Several studies have shown that GenAI tools can improve lesson planning, instructional delivery, personalize learning, facilitate assessment, and support the teaching of complex scientific concepts (Walter, 2024). Nevertheless, effective integration depends on teachers' AI literacy, digital competence, institutional support, professional development, and confidence in using AI responsibly (Holmes et al., 2022). In Nigeria, studies generally report increasing awareness and positive perceptions of GenAI among educators but relatively low classroom utilization because of limited institutional support, insufficient technological resources, inadequate professional training, and uncertainty about its pedagogical and ethical implications (Aliyu, 2024). Despite growing interest in AI integration in teaching and learning, important gaps remain in the literature. Most existing studies have examined awareness, perception, or utilization independently, providing only a fragmented understanding of teachers' readiness to integrate GenAI into classroom practice (Jimba-Na'Allah et al., 2024; Lawal et al., 2025). Consequently, little is known about how these constructs interact to influence teachers' classroom use of GenAI, particularly within subject-specific contexts such as Biology education. Furthermore, empirical evidence focusing on secondary school Biology teachers in Kaduna State remains scarce despite the subject's dependence on visualization, inquiry-based learning, and practical demonstrations that GenAI could potentially support. This lack of context-specific evidence limits the ability of policymakers and education stakeholders to design effective professional development programmes and institutional strategies that promote responsible AI integration in science education.

This study therefore investigated secondary school Biology teachers' awareness, perception, and utilization of Generative AI tools in lesson planning and instructional delivery in Kaduna State, Nigeria through the technology acceptance model. By examining the relationships among these constructs, the study contributes empirical evidence to the growing literature on teachers' readiness for AI integration, extends understanding of technology adoption in science education, and provides evidence to inform educational policy, teacher professional development, curriculum implementation, and institutional strategies for the ethical, effective, and sustainable integration of GenAI into Biology teaching and learning.

1.1 Objectives of the Study

The study sought to:

1. determine the level of secondary school Biology teachers' awareness of Generative AI tools in Kaduna State.
2. examine level of secondary school Biology teachers' perceptions of using Generative AI tools for lesson planning and instructional delivery in Kaduna State.
3. assess the level of secondary school Biology teachers' classroom utilization of AI tools in lesson planning and instructional delivery in Kaduna State.

1.2 Research Questions

The study was guided by the following research questions:

1. What is the level of secondary school Biology teachers' awareness of Generative AI tools in Kaduna State?
2. What is the level of secondary school Biology teachers' perception of using Generative AI tools for lesson planning and instructional delivery in Kaduna State?
3. What is the level of secondary school Biology teachers' utilization of Generative AI tools in lesson planning and instructional delivery in Kaduna State?

2 Literature Review

2.1 Theoretical Framework

The Technology Acceptance Model (TAM), developed by Davis (1989), is one of the most widely used theories for explaining technology adoption. It proposes that acceptance is primarily determined by Perceived Usefulness (PU) the belief that a technology enhances job performance, and Perceived Ease of Use (PEOU) the belief that it is easy to learn and use. These perceptions influence users' attitudes, behavioural intentions, and actual technology utilization (Venkatesh & Davis, 2000). In education, TAM has been widely applied to explain teachers' adoption of digital technologies, including

Artificial Intelligence, showing that educators are more likely to integrate technologies they perceive as useful and easy to use (Al-Abdullatif, 2024). Although awareness is not an explicit TAM construct, this study treats it as an antecedent to technology acceptance, consistent with the Diffusion of Innovations Theory, which identifies awareness as the first stage of the innovation-decision process (Rogers, 2003). Teachers must first be aware of the existence and educational potential of GenAI before evaluating its usefulness and deciding to adopt it. Accordingly, TAM serves as the primary theoretical framework, complemented by the Diffusion of Innovations Theory to explain the role of awareness. Together, these theories provide the basis for examining the relationships among Biology teachers' awareness, perception, and utilization of generative AI tools in lesson planning and instructional delivery in Kaduna State, Nigeria.

2.2 Conceptual Review

Generative Artificial Intelligence (GenAI) differs from traditional rule-based or classificatory AI by its ability to generate original text, images, audio, and other digital content through learning patterns from large datasets rather than simply classifying existing information (Lund & Wang, 2023). In education, GenAI tools include multimodal large language models (e.g., ChatGPT and Google Gemini), productivity assistants (e.g., Microsoft Copilot), conversational agents (e.g., Meta AI and Perplexity), and image-generation systems (e.g., DALL·E and Midjourney), which support lesson planning, instructional content development, assessment, and the creation of visual learning materials (Techasermwattanakul & Suwannatthachote, 2023). Their capabilities are particularly valuable in Biology, where diagrams, simulations, and visual explanations enhance understanding of abstract concepts (Lund & Wang, 2023; Bewersdorff et al., 2025). However, teachers must verify the scientific accuracy of AI-generated content before classroom use because inaccuracies and misinformation may occur (Jobin et al., 2019). Awareness, perception, and utilization constitute the major constructs underpinning teachers' adoption of GenAI. Awareness refers to teachers' knowledge of the existence, functions, educational applications, and ethical implications of GenAI and represents the first stage of technology adoption (Rogers, 2003; Straub, 2009). It is closely associated with AI literacy, which encompasses the competencies required to understand, evaluate, and responsibly use AI technologies (Holmes et al., 2022).

Perception refers to teachers' evaluation of GenAI based on its usefulness, relevance, and ease of use in supporting instruction (Davis, 1989; Ertmer et al., 2016). Teachers who perceive GenAI as improving lesson preparation, explaining complex concepts, and enhancing instructional efficiency are more likely to adopt it. Utilization, however, refers to the actual integration of GenAI into instructional activities, including lesson planning, preparation of teaching materials, generation of visual aids, classroom explanation, and assessment (Walter, 2024). For Biology teachers, meaningful utilization includes generating curriculum-aligned lesson notes, producing diagrams and illustrations, and supporting classroom instruction with AI-generated resources. Although awareness generally shapes perception and perception influences utilization, positive perceptions alone may not guarantee classroom use, particularly where inadequate infrastructure, institutional support, or professional training constrains technology integration (Al-Abdullatif, 2024). Lesson planning involves the systematic organization of instructional objectives, content, learning activities, and assessment to facilitate effective teaching (Esu & Umoren, 2015), while instructional delivery refers to the implementation of these plans in the classroom (Sanusi et al., 2023). In Biology education, where many concepts require visual representation and process-based explanation, GenAI tools can support teachers by generating diagrams, illustrations, and explanatory materials for topics such as photosynthesis, cellular respiration, genetics, and cell structure. The effectiveness of these tools, however, depends on teachers' awareness, positive perceptions, and actual classroom utilization.

2.3 Empirical Review

A growing body of research has examined teachers' engagement Artificial Intelligence (AI) and Generative AI (GenAI) tools, revealing a recurring pattern of uneven awareness, positive perceptions, and relatively low utilization. In Nigeria, Aliyu (2024) found low AI awareness but positive perceptions among secondary school Chemistry teachers in Sokoto State, while Sunday et al. (2025) reported positive perceptions among teachers in Akwa Ibom State despite inadequate training, infrastructure, and institutional support. Similar patterns were reported by Lawal et al. (2025) among Biology teachers in Ilorin and Ibrahim et al. (2025) among Chemistry teachers, whose familiarity with GenAI was concentrated mainly on popular tools such as ChatGPT. Garofalo and Farenga (2024) likewise found that science teachers were cautiously optimistic about GenAI but required structured preparation for effective integration. These findings indicate that teachers may recognize the instructional value of GenAI without possessing broad awareness of its available applications. Evidence on utilization reinforces this pattern. Jimba-Na'Allah et al. (2024) reported moderate awareness but low GenAI integration

among secondary school Biology teachers in Ilorin, while Nuru and Adamu (2025) found low preparedness and utilization among Biology teachers in Ikara, Kaduna State. Kangiwa and Abubakar (2024) and Ekwevugbe (2025) similarly identified gaps between awareness and actual use among academic staff and teacher educators. Across these contexts, limited professional development, inadequate infrastructure, and weak institutional support were recurring barriers. These findings suggest that awareness and positive perceptions do not necessarily translate into sustained classroom utilization.

Studies examining relationships among the constructs provide further evidence that awareness, perception, and utilization are related but may not develop at the same level. David et al. (2025) found a moderate positive relationship between teachers' attitudes toward AI and utilization ($r = .478$, $p < .001$), while Nuru and Adamu (2025) reported a strong relationship between preparedness and AI use ($r = .78$, $p = .001$). Conversely, Olarewaju et al. (2025) found that awareness among pre-service Mathematics teachers did not consistently correspond with utilization. Watted (2025) identified performance expectancy and facilitating conditions as important influences on teachers' intentions to use AI. The evidence therefore suggests that awareness may initiate technology adoption, but positive perceptions and enabling conditions may be important for translating awareness into actual use. Overall, the literature indicates three broad patterns: awareness of GenAI remains uneven; perceptions are generally positive; and utilization is comparatively limited. However, existing findings do not establish a consistent relationship among all three constructs within a single subject-specific population. Most Nigerian studies have examined individual constructs or broader teacher populations across different subject areas. There is particularly limited evidence on the relationships among awareness, perception, and utilization among secondary school Biology teachers in Kaduna State, despite the relevance of GenAI to visualization, inquiry, and explanation of complex biological concepts. The present study therefore addresses this gap by examining these three constructs and determining the relationships among them within this specific population. Guided by this gap and the theoretical framework, the following null hypothesis was tested at the 0.05 level of significance:

H_{01}: There is no significant relationship among awareness, perception, and utilization of Generative AI tools in lesson planning and delivery among Secondary School Biology teachers in Kaduna State.

3 Materials and Methods

3.1 Research Design

This study adopted a descriptive survey research design, appropriate for systematically describing existing conditions, opinions, and practices within a population without manipulating variables (Creswell & Creswell, 2018). The design enabled the collection of factual information from Biology teachers regarding their awareness, perception, and utilization of GenAI tools as these conditions naturally exist, consistent with its established suitability for assessing trends and attitudes in educational research.

3.2 Population and Sample

The population comprised 287 Biology teachers in public Secondary Schools across the seven Local Government Areas (LGAs) of Kaduna Central Zone: Birnin Gwdari, Chikun, Giwa, Igabi, Kaduna North, Kaduna South, and Kajuru. A sample of 169 Biology teachers was determined using the Research Advisors (2006) sample size recommendation table for finite populations. The sample was selected through a multi-stage sampling procedure. First, five LGAs which are Chikun, Igabi, Kaduna North, Kaduna South, and Kajuru, were purposively selected for having comparatively large numbers of Biology teachers and representing both urban and semi-urban settings. Second, proportionate random sampling was used to allocate the sample across the five selected LGAs according to their respective Biology teacher populations. Third, simple random sampling was employed to select individual participants within schools in each selected LGA, giving every Biology teacher an equal chance of inclusion. Table 1 presents the resulting sample distribution.

Table **1**

Sample Distribution of Biology Teachers by Local Government Area

Local Government Area	Population of Biology Teachers	Sample Size
Chikun	41	30

Igabi	45	33
Kaduna North	62	45
Kaduna South	51	37
Kajuru	33	24
Total	**232**	**169**

3.3 Instrumentation

Data were collected using an adapted questionnaire based on the instruments developed by Olaleye and Salami (2024) and Ogba et al. (2024), and modified to suit the objectives of this study. The questionnaire comprised three sections: Section A measured teachers' awareness of ten GenAI tools using a 4-point scale (Highly Aware = 4 to Not Aware = 1); Section B assessed teachers' perceptions of using GenAI tools in lesson planning and instructional delivery on a 4-point Likert scale (Strongly Agree = 4 to Strongly Disagree = 1); and Section C measured teachers' utilization of GenAI tools in instructional tasks using a 4-point frequency scale (Always = 4 to Never = 1). Each section contained ten items, giving a total of 30 items. A benchmark mean of 2.50 was used to classify responses as positive (Aware, Agreed, or Utilized) or negative (Not Aware, Disagreed, or Not Utilized).

3.4 Validity and Reliability

Content and face validity were established through expert review by three specialists in Instructional Technology, Biology Education, and Measurement and Evaluation, who assessed the instrument for clarity, relevance, and alignment with the study objectives. A pilot test involving 20 Biology teachers in Giwa LGA, which shared similar characteristics with the study area but was excluded from the main study, was conducted to assess the instrument's clarity and internal consistency. The instrument yielded a Cronbach's Alpha reliability coefficient of .897, indicating high internal consistency and confirming its suitability for the study.

3.5 Data Collection Procedure

An introductory letter obtained from the Department of Educational Foundations and Curriculum, Ahmadu Bello University, Zaria, was presented to the Kaduna State Ministry of Education and school principals to secure approval. Prior to administration, the purpose of the study was explained to prospective respondents, and participation was entirely voluntary; teachers provided informed consent, and responses were treated with strict confidentiality and used solely for research purposes. The researcher, assisted by three trained research assistants, personally administered and retrieved the questionnaires. All 169 copies distributed were completed and returned, yielding a 100% response rate.

3.6 Data Analysis

Completed questionnaires were coded and analysed using IBM SPSS v27. Means and standard deviations were computed to answer the three research questions, with a benchmark mean of 2.50 used to classify item and overall responses as positive or negative. Pearson Product-Moment Correlation (PPMC) was used to test the null hypothesis regarding the relationship among awareness, perception, and utilization, at the .05 level of significance. The coefficient of determination (r^2) was also computed for each pairwise relationship to indicate the proportion of variance in one construct statistically accounted for by the other.

4 Results

Research Questions 1: What is the level of awareness of various Generative AI tools among Secondary School Biology teachers in Kaduna State?

Table **2**

Teachers' Awareness of Generative AI Tools

Items	n	Mean	SD	Decision
ChatGPT	169	3.57	.542	Aware
Meta AI	169	3.69	.567	Aware
Perplexity	169	2.48	.939	Not Aware
Google Gemini	169	2.34	.823	Not Aware
Microsoft Copilot	169	1.69	.757	Not Aware
Google NotebookLM	169	1.65	.894	Not Aware
DeepSeek	169	2.66	.982	Aware
Canva AI	169	1.54	.664	Not Aware
DALLE-E	169	1.26	.515	Not Aware
Stable Diffusion	169	1.16	.454	Not Aware
Grand Total		**2.20**	**0.71**	**Not Aware**

As presented in Table 2, the overall mean score of 2.20 (SD = 0.71) indicates that secondary school Biology teachers in Kaduna State had a generally low level of awareness of Generative AI tools. Awareness was concentrated on a few widely known conversational AI platforms, particularly Meta AI, ChatGPT, and DeepSeek, whereas awareness of specialized and emerging tools remained limited. This pattern suggests that teachers are more familiar with popular GenAI applications that receive wider public exposure than with subject-specific or content-generation tools that could support instructional planning and classroom practice. The generally low level of awareness implies that many Biology teachers may not yet be sufficiently informed about the diverse range of GenAI tools available for teaching and learning.

Research Question 2: What is the level of secondary school biology teachers' perception of using Generative AI tools in lesson planning and delivery in Kaduna State?

Table **3**

Teachers' Perception of Generative AI Tools in Lesson Planning and Delivery

Item (Abbreviated)	n	Mean	SD	Decision
GenAI tools help develop curriculum-aligned lesson plans	169	3.11	.500	Agreed
GenAI tools can prepare lesson notes & assessment questions	169	3.34	.512	Agreed
GenAI tools generate explanations for complex concepts	169	3.32	.504	Agreed
GenAI tools enhance design of engaging Biology lessons	169	2.80	.600	Agreed
GenAI tools reduce lesson preparation time	169	3.20	.639	Agreed
GenAI tools improve quality of instructional delivery	169	2.91	.548	Agreed
GenAI tools provide useful responses to students' questions	169	2.94	.624	Agreed
GenAI tools support explanation of difficult Biology concepts	169	3.31	.579	Agreed

GenAI tools make lessons more engaging and interactive	169	2.56	.680	Agreed
GenAI tools enhance teachers' efficiency and productivity	169	3.14	.527	Agreed
Grand Total (Cumulative Mean)	**169**	**3.06**	**.57**	**Agreed**

As presented in Table 3, the overall mean score of 3.06 (SD = 0.57) indicates that secondary school Biology teachers in Kaduna State generally held positive perceptions of the use of Generative AI tools in lesson planning and instructional delivery. Respondents expressed confidence in the instructional value of GenAI, particularly for supporting lesson preparation, assessment development, and the explanation of complex biological concepts. Although perceptions regarding the ability of GenAI to enhance lesson engagement and interactivity were comparatively less positive, they remained above the acceptance benchmark, indicating overall acceptance of the technology. These findings suggest that teachers recognize the pedagogical potential of GenAI and are receptive to its integration into Biology instruction.

Research Question 3: What is the level of secondary school biology teachers' utilization of Generative AI tools in lesson planning and instructional delivery in Kaduna State?

Table **4**

Teachers' Utilization of Generative AI Tools in Lesson Planning and Delivery

Item (Abbreviated)	**n**	**Mean**	**SD**	**Decision**
Use GenAI tools to create curriculum-aligned lesson plans	169	1.84	.774	Disagree
Use GenAI tools to generate Biology lesson notes	169	2.45	.912	Disagree
Use GenAI tools to generate diagrams and visuals	169	1.44	.671	Disagree
Use GenAI tools to modify and update existing lesson notes	169	2.35	.818	Disagree
Use GenAI tools to prepare assessment questions	169	1.72	.839	Disagree
Use GenAI tools to simplify instructional delivery	169	1.82	.909	Disagree
Use GenAI chatbots to explain complex Biology concepts	169	2.07	.760	Disagree
Use AI-generated content to enhance student engagement	169	1.49	.691	Disagree
Use AI-generated responses to answer students' questions	169	1.62	.689	Disagree
Use AI-generated questions to assess students	169	1.51	.637	Disagree
Grand Total (Cumulative Mean)	**169**	**1.83**	**.77**	Disagree

As presented in Table 4, the overall mean score of 1.83 (SD = 0.77) indicates a low level of utilization of Generative AI tools among secondary school Biology teachers in Kaduna State. The findings suggest that teachers use GenAI primarily for basic instructional planning activities, such as preparing and revising lesson notes, while its application to broader

instructional tasks, including classroom delivery, student engagement, assessment, and the use of visual learning resources, remains limited. This pattern indicates that although teachers recognize the potential of GenAI, its integration into routine Biology teaching practices is still at an early stage.

Hypothesis Testing

Table **5**

Correlation among Awareness, Perception, and Utilization of Generative AI Tools (N = 169)

Relationship	r	p	r^2 (%)	Decision
Awareness ↔ Perception	.745	< .001	55.5	Significant
Awareness ↔ Utilization	.534	< .001	28.5	Significant
Perception ↔ Utilization	.663	< .001	44.0	Significant

As shown in Table 5, all three pairwise relationships among awareness, perception, and utilization of Generative AI tools were positive and statistically significant, with correlation coefficients ranging from .534 to .745 ($p < .001$). The strongest positive association was observed between awareness and perception, followed by perception and utilization, while awareness and utilization exhibited a moderate positive association. These findings indicate that teachers with higher levels of awareness tended to report more positive perceptions and greater utilization of GenAI tools. Since all *p*-values were less than .05, the null hypothesis was rejected, indicating significant positive associations among awareness, perception, and utilization of Generative AI tools among secondary school Biology teachers in Kaduna State.

5 Discussion

The first finding revealed a low level of awareness of Generative AI tools, indicating that many secondary school Biology teachers in Kaduna state had not acquired adequate knowledge of the wide range of available tools. This finding is consistent with Aliyu (2024) and Sunday et al. (2025), who reported low or uneven awareness of AI tools among teachers in Sokoto and Akwa Ibom States, respectively, and with Ibrahim et al. (2025), who found that Chemistry teachers were familiar mainly with a few popular GenAI tools. From the perspective of the Diffusion of Innovations Theory (Rogers, 2003), this suggests that many Biology teachers in Kaduna State remain at the initial stage of the innovation-decision process, with awareness limited to a few widely known tools rather than the broader range of GenAI tools relevant to Biology instruction. This uneven awareness is likely influenced by limited professional development opportunities and inadequate infrastructure rather than resistance to the technology. It also supports the view that awareness of emerging digital technologies in low-resource educational settings is often gained through informal channels, such as social media, colleagues, and general media coverage, instead of structured, subject-specific professional development that promotes broader knowledge of instructional AI tools (Ng et al., 2021).

The second finding revealed that secondary school Biology teachers in Kaduna State had a positive perception of the use of GenAI tools in lesson planning and instructional delivery. This finding is consistent with Lawal et al. (2025), Ofoegbu et al. (2025), and Akanzire et al. (2025), who reported that teachers and teacher educators viewed GenAI tools favourably because of their potential to improve lesson preparation and instructional delivery. Consistent with the Technology Acceptance Model (Davis, 1989), teachers appear to recognize the usefulness of GenAI tools for instructional tasks such as preparing lesson notes and explaining concepts, despite their limited awareness of the broader range of available tools. This suggests that positive perceptions may develop through experience with a few familiar GenAI tools rather than broad awareness of the wider range of available applications.

The third finding revealed a low level of GenAI tools utilization in lesson planning and instructional delivery among secondary school Biology teachers in Kaduna State. This finding supports a recurring pattern in the Nigerian literature that positive perceptions of GenAI do not always translate into consistent classroom utilization. Jimba Na'Allah et al. (2024) reported a similar pattern among Biology teachers in Ilorin despite moderate awareness, while Kangiwa and Abubakar

(2024) found that although 90% of academic staff were aware of ChatGPT, only about one quarter used it in their academic activities. Likewise, Nuru and Adamu (2025) reported low utilization alongside low preparedness among Biology teachers in Ikara Local Government Area of Kaduna State. From the perspective of the Technology Acceptance Model, these findings suggest a gap between positive attitudes and actual utilization. Consistent with the extended Technology Acceptance Model (Venkatesh & Davis, 2000), external factors such as limited access to digital devices, unreliable internet connectivity, and inadequate institutional support are likely to hinder the translation of positive perceptions into regular classroom utilization.

The significant positive relationships among awareness, perception, and utilization from the findings of the hypotheses test indicates that these constructs are closely related. The strong relationship between awareness and perception ($r = .745$, $r^2 = 55.5\%$) suggests that the two variables shared 55.5% of their variance, indicating that teachers with greater awareness of GenAI tools were more likely to develop positive perceptions of their instructional value. By contrast, awareness and utilization shared only 28.5% of their variance ($r = .534$, $r^2 = 28.5\%$), indicating that awareness alone had a relatively weaker relationship with classroom utilization. However, perception showed a stronger relationship with utilization ($r = .663$, $r^2 = 44.0\%$), suggesting that teachers' perceptions shared 44.0% of the variance with their utilization of GenAI tools. This finding supports David et al. (2025), who reported a moderate positive relationship between teachers' attitudes and AI utilization, while extending previous evidence by showing that perception is more strongly associated with utilization than awareness. Consistent with the Technology Acceptance Model and the Diffusion of Innovations Theory, the findings suggest that awareness contributes to the development of positive perceptions, whereas perception has a more direct relationship with classroom utilization. This further indicates that increasing teachers' awareness alone may not substantially improve GenAI tools utilization unless accompanied by positive perceptions and adequate institutional support.

The strength of the relationships observed in this study is also comparable with previous research. The strong awareness-perception relationship ($r = .745$) and the moderate perception-utilization relationship ($r = .663$) are broadly consistent with the strong preparedness-utilization relationship reported by Nuru and Adamu (2025) among Biology teachers in Ikara Local Government Area of Kaduna State ($r = .78$). Similarly, the awareness-utilization relationship ($r = .534$) was slightly stronger than the attitude-utilization relationship reported by David et al. (2025) among secondary school teachers ($r = .478$). These findings suggest that although the relationships among awareness, perception, and utilization are generally consistent across studies, their strength may differ depending on the subject area and the specific GenAI tools examined.

6 Limitations of the Study

This study has some limitations that should be considered when interpreting its findings. The cross-sectional design limits the ability to establish changes over time or causal relationships among awareness, perception, and utilization of Generative AI. The use of self-reported questionnaire data may also introduce response or social desirability bias. In addition, the study was limited to secondary school Biology teachers in Kaduna central zone, which may constrain the generalizability of the findings to other locations, subject areas, or educational contexts. Finally, the study focused primarily on awareness of a limited number of widely known GenAI tools and may not fully reflect teachers' awareness of the broader and rapidly evolving range of GenAI applications.

7 Conclusion

This study examined secondary school Biology teachers' awareness, perception, and utilization of Generative AI tools in lesson planning and instructional delivery in Kaduna State and investigated the relationships among these constructs. The findings revealed that although teachers held positive perceptions of the instructional value of GenAI tools, they demonstrated low awareness of the broader range of available tools and low classroom utilization. Awareness, perception, and utilization were significantly and positively related, with perception showing a stronger relationship with utilization than awareness. These findings suggest that while teachers have a positive perception toward GenAI tools, limited awareness and inadequate institutional support continue to hinder its effective classroom integration. Therefore, education authorities and school administrators should provide structured professional development that expands teachers' awareness of GenAI tools and strengthen the infrastructural and institutional support needed for sustained classroom utilization. Future research should examine these relationships across other science subjects and educational zones using longitudinal designs to establish their generalizability and causal direction.

8 Declarations

Ethical Statements: This study involved voluntary participation of Secondary School Biology teachers, and informed consent was obtained from all respondents prior to questionnaire administration. Institutional approval to conduct the study was obtained from the Department of Educational Foundations and Curriculum, Ahmadu Bello University, Zaria, and permission was subsequently granted by the Kaduna State Ministry of Education and participating school authorities. No identifying information was collected, and all data were treated with strict confidentiality and used solely for the purposes of this research.

Conflict of Interest: The authors declare neither financial nor non-financial conflict of interest.

Author Contributions: YM conceptualized the study, developed the research instrument, collected and analysed the data, and drafted the manuscript. SM supervised the design and analysis, provided critical revisions to the theoretical framing, and approved the final manuscript for submission. MCHB supervised the data collection process, reviewed the methodology and results, and critically revised the manuscript for intellectual content. All authors read and approved the final manuscript.

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Data Availability Statement: The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

9 References

Akanzire, B. N., Nyaaba, M., & Nabang, M. (2025). Generative AI in teacher education: Teacher educators' perception and preparedness. *Journal of Digital Educational Technology, 5*(1), ep2508. https://doi.org/10.30935/jdet/15887

Al-Abdullatif, A. M. (2024). Modeling teachers' acceptance of generative artificial intelligence use in higher education: The role of AI literacy, intelligent TPACK and perceived trust. *Education Sciences, 14*(11), 1209. https://doi.org/10.3390/educsci14111209

Aliyu, F. (2024). Teachers' awareness and perception on utilization of artificial intelligence as a tool for teaching and learning of chemistry at secondary schools in Sokoto State. *Rima International Journal of Education, 3*(4), 169–179.

Bewersdorff, A., Hartmann, C., Hornberger, M., Seßler, K., Bannert, M., Kasneci, E., Kasneci, G., Zhai, X., & Nerdel, C. (2025). Taking the next step with generative artificial intelligence: The transformative role of multimodal large language models in science education. *Learning and Individual Differences, 118*, Article 102601. https://doi.org/10.1016/j.lindif.2024.102601

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative and mixed methods approaches* (5th ed.). SAGE Publications.

David, E. T., Nnaemeka, G. U., Akuneme, C. C., & Nwosu, C. K. (2025). AI in education: A cross-sectional study on teachers' attitudes towards AI integration and usage in secondary schools. *Journal of Theoretical and Empirical Studies in Education*, Special Issue, 417–435.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340. https://doi.org/10.2307/249008

Ekwevugbe, A. O. (2025). Use of artificial intelligence technology for revolutionizing teaching and learning practices in teacher education programmes in Nigeria. *International Journal of Innovative Information Systems & Technology Research, 13*(4), 33–39. https://doi.org/10.5281/zenodo.17394722

Ertmer, P. A., Ottenbreit-Leftwich, A., & York, C. S. (2016). Exemplary technology-using teachers: Perceptions of factors influencing success. *Journal of Computing in Teacher Education, 23*(2), 55–61.

Esu, A. E. O., & Umoren, G. (2015). *Fundamentals of elementary education*. Stiffaith Prints.

Federal Ministry of Communications, Innovation and Digital Economy. (2023). *National artificial intelligence strategy (NAIS)*. Government of Nigeria.

Garofalo, S. G., & Farenga, S. J. (2024). Science teacher perceptions of the state of knowledge and education at the advent of generative artificial intelligence popularity. *Science & Education, 34*(4), 893–912. https://doi.org/10.1007/s11191-024-00534-y

Holmes, W., Bialik, M., & Fadel, C. (2022). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.

Ibrahim, A., Ahmed, A. A., & Oyeyemi, W. T. (2025). Accessibility and usability of generative AI for teaching among secondary school chemistry teachers in Ilorin Metropolis, Kwara State. *Journal of Science Education and Innovation, 3*(1), 45–56. https://doi.org/10.5281/zenodo.15229924

Jimba-Na'Allah, F. K., Buhari, G. F., Bolaji, H. O., & Makinde, S. O. (2024). Instructional methods and generative AI integration for classroom teaching among secondary school biology teachers in Ilorin, Kwara State. *International Journal of Innovative Technology Integration in Education, 7*(2), 23–38.

Jobin, A., Ienca, M., & Vayena, E. (2019). The global landscape of AI ethics guidelines. *Nature Machine Intelligence, 1*, 389–399. https://doi.org/10.1038/s42256-019-0088-2

Kangiwa, B. I., & Abubakar, N. S. (2024). Awareness and utilization of ChatGPT among academic staff of Federal College of Education (Technical), Bichi. *International Journal of Educational Research and Library Science, 4*(8), 193–204.

Lawal, O. A., Obeten, O. M., Olowookere, A. K., Lagbel, G., Elechi, U. S., & Onyebuchi, E. O. (2025). Assessment of implementation of artificial intelligence tools in biology teaching and learning at secondary schools in Ilorin, Nigeria. *Journal of Pharma Insights and Research, 3*(2), 211–217. https://doi.org/10.69613/41z5vh71

Lund, B. D., & Wang, T. (2023). Chatting about ChatGPT: How may AI and GPT impact academia and libraries? *Library Hi Tech News, 40*(3), 26–29. https://doi.org/10.1108/LHTN-01-2023-0009

Nuru, R. A., & Adamu, T. A. (2025). Assessment of Biology teachers' preparedness and challenges of integrating artificial intelligence tools at secondary school level in Ikara, Kaduna State. *Zamfara International Journal of Science, Technology, Education & Mathematics, 1*(1), 452–464. https://doi.org/10.5281/zenodo.15229924

OECD. (2023). *OECD digital education outlook 2023: Opportunities, guidelines and guardrails for effective and equitable use of AI in education*. OECD Publishing.

Ofoegbu, J. U., Osang, A. W., Chidozie, V. N., & Eke, O. E. (2025). Perception of Nigerian teacher educators on benefits and challenges of integrating AI powered tools in classroom instruction for national development in Nigeria. *LWATI: A Journal of Contemporary Research, 22*(2), 98–114.

Ogba, F. N., Ogar, J. O., & Igu, N. C. N. (2024). Examining teachers' use of AI tools for instructional quality in Nigerian universities. *Journal of Association of Educational Management and Policy Practitioners, 6*(1), 25–33.

Olaleye, D. O., & Salami, I. A. (2024). Basic science and technology teachers' attitude and intention-to-use AI for lesson planning and delivery: The narratives in Oyo State, Nigeria. *International Journal of Research and Innovation in Social Science*. https://doi.org/10.47772/IJRISS.2024.803305S

Olarewaju, A. O., Moshood, A., & Awoyemi, S. A. (2025). Pre-service teachers' awareness and utilization of AI tools in mathematics education: Evidence from Kwara State, Nigeria. *Al-Hikmah Journal of Education, 12*(1), 86–97.

Research Advisors. (2006). *Sample size table*. https://www.research-advisors.com/tools/SampleSize.htm

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.

Sanusi, K. F., Ali, M. M., & Isiaka, K. O. (2023). Assessment of the teachers' perception on the use of lesson plan in classroom lesson's delivery in secondary school in North West geo-political zone, Nigeria. *Journal of Curriculum and Instruction, 14*(1), 12–24.

Sarker, I. H. (2022). AI-based modeling: Techniques, applications and research issues towards automation, intelligent and smart systems. *SN Computer Science, 3*(2), 158. https://doi.org/10.1007/s42979-022-01043-x

Straub, E. T. (2009). Understanding technology adoption: Theory and future directions for informal learning. *Review of Educational Research, 79*(2), 625–649. https://doi.org/10.3102/0034654308325896

Sunday, G. I., Bassey, E. J., Essien, A. E., Udoh, U. S., & Paul, U. E. (2025). Teachers' perceptions of the integration of artificial intelligence tools in classroom instruction and academic performance in secondary schools in Akwa Ibom State, Nigeria. *ISIR Journal of Arts, Humanities and Social Sciences, 2*(2), 57–70.

Techasermwattanakul, P., & Suwannatthachote, P. (2025). The application of generative AI in educational research: A systematic literature review. *Journal of Education and Innovation, 27*(1), 160–174. https://doi.org/10.71185/jeiejournals.v27i1.278408

UNESCO. (2021). *Recommendation on the ethics of artificial intelligence*. UNESCO Publishing. https://unesdoc.unesco.org/ark:/48223/pf0000381137

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science, 46*(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926

Walter, A. (2024). Utilizing language-generating artificial intelligence in educational planning: A case study. *Journal of Interdisciplinary Teacher Leadership, 8*(1), 29–59.

Watted, A. (2025). Teachers' perceptions and intentions toward AI integration in education: Insights from the UTAUT model. *Power System Technology, 49*(2), 164–183. https://powertechjournal.com/index.php/journal/article/view/1759.

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