

# Integration of Artificial Intelligence (AI) for effective teaching and learning of chemistry in colleges of education in South East Nigeria

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## Abstract

The study assessed the integration of Artificial Intelligence (AI) for effective teaching and learning of Chemistry in colleges of education in South-East Nigeria, particularly Anambra and Ebonyi State. The research design was descriptive survey research design. The study was guided by three research questions and two hypotheses. The population of the study was 226, which consisted of both lecturers and students from two colleges of Education in Anambra and Ebonyi states; 115 from Nwafor Orizu College of Education Nsugbe and 111 from Federal college of Education Technical, Isu. purposive random sampling technique was used to select 180 lecturers and students for the study. The study used 165 final year undergraduate students (68 male students and 97 female students) and 15 lecturers (6 male and 9 female). The instrument for data collection was a structured questionnaire "Integration of Artificial Intelligence in Teaching and Learning of Chemistry in Colleges of Education" (IAITLCCE). To ensure the validity of the instrument the researcher submitted the questionnaire to two experts each from department of Chemistry and department of Psychology (measurement and evaluation specialist), both in Nsugbe and Isu. The reliability coefficient was established as 0.81 using test-retest method. Mean and standard deviation were used to answer the three research questions, while t-test statistic was used to answer the hypotheses at 0.05 level of significance. The findings of this study among others showed that both students and lecturers perceived that Artificial Intelligence (AI) is integrated to a moderate extent in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria. Also, the challenges encountered by institutions towards incorporating AI into the chemistry education are the high cost of AI tools, insufficient resources, poor training of teachers and students, difficulty in integrating AI into the existing curriculum and poor knowledge of the ethical considerations of AI. Although, the study reveals a generally positive perception of the benefits of AI in Chemistry education. Conclusion and recommendations were made among others is the establishment of partnerships with technology companies to provide students with internship opportunities and lecturers with professional training focused on AI and its usage in education.

## 1. Introduction

Chemistry is one of the science subjects upon which technological breakthrough is built and it is also the pivot on which the wheel of science rotates. Chemistry contributes to human health care system, improved agriculture, helped in environmental pollution remediation and control, improved in manufacturing and process industries like textile and food industries (Ibe et al., 2021). Chemistry is a practical-oriented and universal discipline of science whose principles cut across all aspects of scientific and technological development (Ezeliora et al., 2021). The universality of Chemistry is rooted in the broader principle of the universality of science, which emphasizes freedom of movement, association, expression, and communication among scientists, as well as equitable access to data, information, and research materials (Ezeiheukwu et al., 2024). Ibe et al (2024) stated that as a core component of science education, the teaching and learning of Chemistry play a crucial role in higher education systems in both developed and developing countries. Chemistry education, as observed by Ibe et al (2024), remains an active and evolving field of research that bridges the discipline of Chemistry with educational theory and practice. It focuses primarily on how Chemistry is taught and learned in schools, colleges, and universities, with the aim of improving students' understanding, cognitive development, and problem-solving abilities (Ibe & Ikokwu, 2025). One of the fundamental goals of Chemistry education is therefore to equip learners with higher-order thinking skills and the capacity to apply scientific knowledge to real-life situations. However, the

attainment of these goals has often been constrained by the inability to effectively and positively utilise emerging instructional technologies (Nwafor et al., 2022).

In recent years, the rapid development of Information and Communication Technology (ICT) has significantly influenced science education, including Chemistry education. Building on this ICT advancement, artificial intelligence (AI) has emerged as a powerful innovation capable of further transforming Chemistry teaching and learning (Ibe & Okosun, 2025). AI supports the universality of science education including Chemistry education by enabling wider access to learning resources, virtual laboratories, simulations, intelligent tutoring systems, and real-time collaboration across geographical boundaries (Kuleto et al., 2021). They further stated that through AI-driven platforms, students and educators can freely access data, share ideas, and engage in scientific inquiry, thereby reinforcing the universal nature of Chemistry as a discipline.

Artificial Intelligence can be described as an innovative technological framework that enables computer systems to perform tasks that traditionally require human intelligence, including problem-solving, knowledge acquisition, language processing, and visual recognition (Mhlanga, 2021). It encompasses intelligent systems designed to replicate rational human thought and decision-making (Jain & Jain, 2019). In higher education such as colleges of education, AI has already brought significant changes by enabling tailored learning experiences, intelligent tutoring, and immediate feedback for learners. Adaptive learning platforms, virtual simulations, and intelligent tutoring systems have enhanced instructional delivery by accommodating different learning needs and improving learner engagement. A systematic review by Slimi (2021) revealed that AI enhances higher education by fostering personalized learning, developing e-learning systems, and improving data-driven decision-making, all of which are essential for subjects like Chemistry. Importantly, AI is not intended to replace teachers. While earlier attempts in education considered such possibilities, current perspectives emphasize AI as a complementary tool rather than a substitute (JISC, 2021; Nwafor & Tsakeni, 2025). Teaching is a multidimensional process that goes beyond content delivery to include the development of social, emotional, and critical thinking skills, which AI cannot fully replicate (Kolchenko, 2018). In agreement, Chan and Tsi (2023) concluded that although AI can enhance instructional practices, human instructors remain irreplaceable due to their unique abilities in creativity, emotional intelligence, and social interaction. Thus, the current focus is on preparing educators with AI literacy, ethical considerations, and practical skills to effectively integrate AI in teaching and learning environments. Applications of AI in education are diverse and include chatbots and digital assistants, adaptive and personalized learning systems, automated grading, intelligent simulations, predictive analytics, virtual laboratories, and emotional AI tools. These innovations improve not only teaching and learning processes but also assessment methods, preparing students for future employment in a technology-driven economy (Slimi, 2021). The integration of artificial intelligence into Chemistry education aligns with national educational goals and policy directives. The National Policy on Education and Major Reforms and Innovation (2012) emphasizes that teacher education must continuously adapt to changes in methodology and curriculum, and that teachers should be regularly exposed to professional innovations. AI represents one such innovation, offering new pedagogical approaches that enhance practical learning, personalised instruction, and effective assessment in Chemistry. Similarly, the National Commission for Colleges of Education (NCCE, 2010) underscores that the quality of teachers in public schools is directly linked to the quality of training they receive during teacher preparation programmes. Incorporating AI into these programmes equips prospective Chemistry teachers with relevant digital and analytical skills needed to meet contemporary educational demands. Furthermore, Nwafor and Tsakeni (2025) stated that the use of AI in Chemistry education contributes to national and global competitiveness by preparing graduates with the knowledge, skills, and technological competence required in a modern, knowledge-driven economy. AI-supported learning environments foster critical thinking, creativity, problem-solving skills, and scientific inquiry competencies essential for meaningful participation in the global economy. The rise of digitalization has therefore compelled higher institutions, including Colleges of Education, to remain alert to emerging technological advancements and incorporate them into their teaching practices (Aldosari, 2020).

### **1.1. Statement of Problem**

Chemistry, as a core science subject, plays a vital role in the training of students in science and technology disciplines. However, its teaching and learning in Nigerian colleges of education have continued to face numerous challenges. Overcrowded classrooms, inadequate instructional resources, and the predominant reliance on traditional lecture methods often result in poor student engagement, low retention, and unsatisfactory academic performance. These difficulties are particularly evident in General Chemistry, a compulsory course with large student enrollment, where many learners struggle to understand abstract concepts and apply them effectively. With the rapid advancement of digital technologies, artificial intelligence (AI) offers innovative tools and strategies that can potentially transform teaching and learning by providing adaptive learning, personalized instruction, interactive simulations, and timely feedback. Despite the proven benefits of AI integration in education globally, its adoption in Nigerian colleges of education especially in the teaching of Chemistry remains limited, poorly structured, and under-researched. Teachers often lack the required AI literacy, while issues of ethical use, infrastructural support, and proper pedagogical integration further complicate its implementation. At Colleges of Education in South East, these challenges remain evident, as students continue to face difficulties in mastering Chemistry concepts through conventional methods. Yet, little is known about the actual influence of integrating AI tools into Chemistry instruction. Therefore, it is against this background, the researcher wants to investigate the integration of artificial intelligence (AI) for effective teaching and learning of Chemistry in colleges of education in south east Nigeria, with a view to identifying its benefits, challenges, and practical implications.

### **1.2. Theoretical Framework**

This study was anchored on Vygotsky's Social Constructivist Learning Theory, this theory has a significant implication for the integration of Artificial Intelligence (AI) in the teaching and learning. Vygotsky's Social Constructivist Theory emphasizes that learning is a social process that occurs through interaction, collaboration, and scaffolding within a learner's environment. The theory suggests that students learn better when they engage actively with peers, teachers, and learning tools that support their cognitive development. This theory underpins the study because the innovations of using digital technologies, such as Artificial intelligence, are important for delivering instructions in Chemistry education. The use and adoption of AI usually originates from the teachers and educational administrators and then spreads or diffuses to the students and schools at an incremental level. Through this, the students acquire a level of skills and apply the innovations (artificial intelligence) in solving many problems through the use of better innovative practices and techniques. The application of this theory of innovation is of importance to this research work and the development of human capacity in not just Chemistry education but science education.

### **1.3. Research Questions**

The following research questions guided the study:

- a. To what extent do lecturers and students perceive AI integration in teaching and learning of Chemistry in Colleges of Education in South-East Nigeria?
- b. What are the challenges encountered by lecturers and students in integrating AI in teaching and learning of Chemistry in Colleges of Education in South-East Nigeria?
- c. What are the benefits derived from integrating AI in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria?

### **1.4. Hypotheses**

The study was guided by two null hypotheses and tested at a 0.05 level of significance.

- a. There is no significant difference between the mean response of the lecturers and students on the extent of AI integration in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria.

- b. There is no significant difference between the mean response of the lecturers and students in the challenges encountered when integrating AI in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria.

## 2. Method

The study employed a quantitative approach, specifically, a descriptive survey research design. Descriptive survey research involves the collection of data from a sample of the population considered a representative of the entire group (Nworgu, 2018). This design is considered fitting because the views of the respondents (lecturers and students) were collected and analysed to determine the extent of AI utilization in Chemistry education. The participants included the 165 final year undergraduate students (68 male students and 97 female students) and 15 lecturers (6 male and 9 female) both from Department of Chemistry College of Education Nsugbe Anambra State, Nigeria (95 Chemistry students & 6 lecturers) and Department of Chemistry Federal college of Education Technical, Isu Ebonyi State, Nigeria (70 Chemistry students & 9 lecturers). To gather data, the researcher develops an instrument titled "*Integration of Artificial Intelligence in Teaching and Learning of Chemistry in Colleges of Education (IAITLCCE)*" which was distributed to both students and lecturers at the participating institutions. The questionnaire's reliability was confirmed prior to its administration. Three experts performed the face validation of the instrument. Cronbach Alpha was used to calculate the internal consistency, and the result was an estimate of 0.89. There were four sections of the questionnaire. While Section "A" contained the respondents' biographical information. Section "B" contains 10 items the assessment utilized a four-point rating scale to evaluate various items, included categories such as Very High Extent, (VHE) assigned a value of 4 points to indicate a significant degree of agreement or presence; High Extent, (HE) which received 3 points to reflect a strong but not absolute affirmation; Low Extent, (LE) worth 2 points to represent a minor level of agreement; and Very Low Extent, (VLE) with a score of 1 point to denote minimal acknowledgment or presence. Section "C" and "D" contained 20 items organised according to a modified four-point Likert scale: Agree (A) = 3, Disagree (D) = 2, and Strongly Disagree (SD) = 1. To address a specific research question, descriptive statistics were employed, which included calculating mean scores and standard deviations. Additionally, a t-test was used to evaluate the hypotheses at 95% confidence interval using the independent sample t-test in SPSS Version 25. The mean scores rating were categorized into three groups: low extent for scores of 2.49 and below, moderate extent for scores ranging from 2.50 to 3.49, and high extent for scores between 3.50 and 4.00. Any item with a mean rating of 2.5 and above indicated a positive response or agreement, while items with a mean rating of 2.49 and below indicated a negative response or disagreement.

## 3. Results and Discussion

### 3.1. Results

This section presents the results of the study in line with the research objectives. Responses to the questionnaire were assessed using a four-point Likert scale, where a score of one (1) represented strong disagreement and a score of four (4) represented strong agreement with the statements.

#### 3.1.1. Demographic Information

The study involved a total of 180 participants, comprising 165 final-year undergraduate Chemistry students (68 males and 97 females) and 15 Chemistry lecturers (6 males and 9 females). The participants were drawn from the Department of Chemistry, Nwafor Orizu College of Education, Nsugbe, Anambra State, Nigeria (95 students and 6 lecturers), and the Department of Chemistry, Federal College of Education (Technical), Isu, Ebonyi State, Nigeria (70 students and 9 lecturers).

Most of the students were between 18 and 20 years of age, while the lecturers were between 30 and 50 years old. All lecturers held at least a master's degree in Chemistry or a related field.

#### 3.1.2. Research Question

- a. Research Question 1: To what extent do lecturers and students perceive AI integration in teaching and learning of Chemistry in Colleges of Education in South-East Nigeria?

Mean, standard deviation and decision rule of extent lecturers and students perceive ai integration in teaching and learning of chemistry in colleges of education in South-East Nigeria can be seen in Table 1.

**Table 1. Mean, Standard Deviation and Decision rule of extent lecturers and students perceive AI integration in teaching and learning of Chemistry in Colleges of Education in South-East Nigeria**

S/N	Item	N	Mean	Std. Deviation	Decision
Q1	Deep Learning classes are part of the chemistry education program at my school.	180	3.2500	0.74664	Moderate Extent
Q2	Artificial intelligence courses are introduced early in my school to provide opportunities to learn more about the subject.	180	3.1379	0.83767	Moderate Extent
Q3	The chemistry education curriculum includes robotics assignments and projects as part of core course assignments.	180	2.8605	0.90959	Moderate Extent
Q4	There are sufficient lecturers with AI expertise to teach AI and related courses.	180	2.7471	0.90500	Moderate Extent
Q5	The chemistry education programmes have sufficient computing resources and software tools for hands-on AI instruction.	180	2.7011	0.96587	Moderate Extent
Q6	The chemistry education curriculum covers the ethical implications of artificial intelligence.	180	2.8046	0.97455	Moderate Extent
Q7	Chemistry education programmes have sufficient access to datasets for hands-on AI instruction.	180	2.6818	0.90396	Moderate Extent
Q8	AI-based personalised learning is a valuable addition to chemistry education.	180	3.3523	0.72777	Moderate Extent
Q9	I feel confident using AI tools independently for teaching and learning chemistry.	180	3.1136	0.79411	Moderate Extent
Q10	I prefer a combination of AI-based learning and traditional classroom teaching for chemistry.	180	3.2500	0.77682	Moderate Extent
Grand Mean / SD			2.9899	0.892	Moderate Extent

Table 1 revealed a broadly moderate perception of AI integration in Chemistry education across lecturers and students in South-East Nigeria. With a grand mean of 2.9899 and grand SD of 0.892, respondents however near the midpoint, indicating neither strong endorsement nor strong opposition to AI-enhanced teaching. Individual items cluster around “Moderate Extent,” though Item 8 (AI-based personalized learning) shows a slightly higher mean (3.3523), suggesting some openness to AI as a valuable addition.

b. Research Question 2: What are the challenges encountered by lecturers and students in integrating AI in Chemistry education in Colleges of Education in South-East Nigeria?

Mean, standard deviation and decision of challenges encountered by lecturers and students in integrating ai in chemistry education in colleges of education in South-East Nigeria can be seen in Table 2.

**Table 2. Mean, Standard Deviation and Decision of challenges encountered by lecturers and students in integrating AI in Chemistry education in Colleges of Education in South-East Nigeria**

S/N	Item	N	Mean	Std. Deviation	Decision
Q1	High cost of installing and maintaining AI tools required for teaching and learning.	180	3.3034	0.74475	Agree
Q2	Insufficient resources.	180	3.1573	0.73699	Agree
Q3	Irregular electricity supply hampering the utilization of e-learning.	180	3.3034	0.71358	Agree
Q4	Difficulty in integrating AI into the existing curriculum.	180	3.0787	0.72652	Agree
Q5	Poor knowledge of the ethical considerations of artificial intelligence.	180	3.0899	0.77812	Agree
Q6	Dearth of skilled manpower for the implementation and management of available AI tools for impactful knowledge delivery.	180	3.1685	0.69472	Agree
Q7	Poor training of teachers and students on how to use AI tools, especially educational technologies.	180	3.1461	0.79130	Agree
Q8	Resistance to change from traditional pedagogical methods to innovative, technology-based teaching and learning approaches.	180	3.1573	0.78188	Agree
Q9	Limited access to devices or the internet (insufficient bandwidth).	180	3.1348	0.82835	Agree

Q10	Technical issues experienced while using AI platforms (e.g., poor connectivity, device problems).	180	3.2022	0.74131	Agree
Grand Mean / SD			3.1742	0.79	Agree

Table 2 shown pervasive challenges in integrating AI into Chemistry education in South-East Nigeria. With a grand mean of 3.174 and a relatively low standard deviation (0.79), respondents broadly agree on several hurdles. High costs of installation and maintenance (Q1) and irregular electricity (Q3) emerge as dominant barriers, followed by resource constraints (Q2) and curriculum integration difficulties (Q4). Ethical awareness (Q5) and skilled manpower (Q6) also pose concerns, as do training gaps (Q7) and resistance to change (Q8). Limited device or internet access (Q9) and technical issues (Q10) further hinder adoption.

- c. Research Question 3: What are the benefits derived from integrating AI in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria?

Mean, standard deviation and mean benefits derived from integrating ai in the teaching and learning of chemistry in colleges of education in South-East Nigeria can be seen in Table 3.

**Table 3. Mean, Standard Deviation and Mean benefits derived from integrating AI in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria**

S/N	Item	N	Mean	Std. Deviation	Decision
Q1	AI integration enhances students' understanding of complex chemistry concepts.	180	3.2809	0.62138	Agree
Q2	AI tools help improve students' academic performance in chemistry.	180	3.1685	0.66120	Agree
Q3	AI applications promote individualized learning and mastery of chemistry topics.	180	3.2022	0.74131	Agree
Q4	AI enhances students' problem-solving and critical thinking skills in chemistry.	180	3.2921	0.69417	Agree
Q5	Students are more motivated to participate in chemistry classes when AI tools are used.	180	3.1910	0.75191	Agree
Q6	AI increases students' curiosity and desire to explore chemistry beyond the classroom.	180	3.2247	0.75004	Agree
Q7	Integration of AI reduces students' fear and anxiety toward learning chemistry.	180	3.2022	0.78595	Agree
Q8	AI tools stimulate creativity and innovation in teaching chemistry.	180	3.1348	0.80044	Agree
Q9	Students use AI platforms to design experiments and visualize chemical processes.	180	3.2697	0.71928	Agree
Q10	AI assists in chemistry research and data analysis for both students and lecturers.	180	3.4944	0.65926	Agree
Grand Mean / SD			3.2461	0.727	Agree

Table: Perceived Benefits of Artificial Intelligence Integration in Chemistry Education

Table 3 revealed a broadly positive view of AI's benefits in Chemistry education across Colleges of Education in South-East Nigeria. With a grand mean of 3.2461 and a standard deviation of 0.727, respondents consistently agree that AI enhances understanding of complex concepts, improves performance, supports individualized learning, and boosts problem-solving, engagement, curiosity, and creativity. Notably, AI also aids in designing experiments, visualizing processes, and supporting research and data analysis for both students and lecturers (Q10).

### 3.1.3. Hypotheses

- a.  $H_{01}$ : There is no significant difference between the mean response of the lecturers and students on the extent of AI integration in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria.

T- test table of difference between the mean response of the lecturers and students on the extent of ai integration in the teaching and learning of chemistry in colleges of education in South-East Nigeria can be seen in Table 4.

**Table 4. T- test table of difference between the mean response of the lecturers and students on the extent of AI integration in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria**

t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
54.569	179	0.060	2.98764	2.8788	3.0964

Table: One-Sample t-Test Summary

Table 4 above independent samples t-test which compares lecturers' and students' views on AI integration in Chemistry education. The test yields  $t(179) = 54.569$ ,  $p = 0.060$ , with a mean difference of 2.9876 (95% CI: 2.8788 to 3.0964). Although the difference appears sizable, the p-value exceeds the conventional 0.05 threshold, so we fail to reject  $H_{01}$  at 5% significance. So the hypothesis which stated that there is no significant difference between the mean response of the lecturers and students on the extent of AI integration in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria is therefore uphold.

- b.  $H_{02}$ : There is no significant difference between the mean response of the lecturers and students in the challenges encountered when integrating AI in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria.

T- test table of difference between the mean response of the lecturers and students in the challenges encountered when integrating ai in the teaching and learning of chemistry in colleges of education in South-East Nigeria can be seen in Table 5.

**Table 5. T- test table of difference between the mean response of the lecturers and students in the challenges encountered when integrating AI in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria**

t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
63.70	179	0.000	0.35661	0.3455	.3677

Table: One-Sample t-Test Result

Table 5 indicated the null hypothesis posits no difference in lecturers' and students' reported challenges with AI in Chemistry education in colleges of education in south east, Nigeria. With  $t(179) = 63.70$  and  $p < .001$ , the result strongly rejects the null hypothesis, indicating a significant difference between groups. The mean difference is 0.3566 (95% CI: 0.3455 to 0.3677), suggesting one group experiences notably more challenges than the other.

### 3.2. Discussion

The study revealed that the extent of AI integration perceived in the teaching and learning of Chemistry across Colleges of Education in South-East Nigeria is moderate. Further analysis showed that there is no significant difference between the mean scores of lecturers and students regarding the extent of AI integration in Chemistry education, as both groups agreed that AI integration is at a moderate level. This finding is consistent with the studies of Nwafor and Tsakeni (2025) and Park et al (2023), who reported that the use of AI is still at a nascent stage in most Nigerian institutions due to challenges such as limited AI resources and insufficient expertise among academic communities. Similarly, Musa and Abdulkadir (2025) disclosed that, due to inherent barriers to AI adoption in schools, many Nigerian institutions lack the capacity to ensure successful integration of AI into tertiary education programmes.

Conversely, the findings of this study differ from those of Nwodu, (2025), who reported high levels of AI integration in Chinese and Portuguese universities, respectively. Likewise, the present study contradicts the findings of Slimi (2021), who observed that AI courses are taught across K-12, computer science, and science curricula in the United States of America. These differences may be attributed to the greater availability of AI-driven tools and stronger institutional support in the educational systems of these countries. In line with Kuleto et al (2021), the present results suggest that although awareness and acceptance of AI in Chemistry education are increasing, its integration remains at a developmental stage in Colleges of Education in South-East Nigeria. This moderate level

of integration highlights the need for improved infrastructure, capacity building for lecturers, curriculum enhancement, and increased access to AI tools and datasets to strengthen AI-driven teaching and learning in higher institutions.

The study also identified several challenges encountered by institutions in integrating AI into Chemistry education, including the high cost of AI tools, inadequate resources, insufficient training of teachers and students, difficulties in integrating AI into the existing curriculum, and limited knowledge of AI ethical considerations. These findings corroborate those of Nwafor and Tsakeni (2025), who reported that AI implementation in Nigeria is constrained by a lack of institutional support, insufficient AI resources, ethical concerns, and the limited capacity of teachers and students to effectively utilize AI-generated data and tools. Similarly, Pedrof (2020) observed that major barriers to AI implementation in developing countries such as Nigeria include poor infrastructure, limited knowledge of AI among teachers and students, and weak institutional support. In addition, the findings align with those of Park et al (2023), who identified inadequate funding, limited access to AI-driven tools, cultural resistance, and poor internet connectivity as major constraints to AI adoption in education.

Although these challenges, the results revealed a broadly positive perception of the benefits derived from integrating AI into the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria. Respondents generally agreed that AI integration contributes significantly to improved teaching and learning outcomes in Chemistry. In line with Musa and Abdulkadir (2025), the findings indicate that AI enhances students' understanding of complex topics and improves their academic performance. The use of AI applications was also perceived to promote individualized learning and mastery of subject content, thereby addressing learners' diverse abilities and learning paces. Furthermore, the findings are consistent with those of Park et al (2023), who reported that AI integration increases students' motivation, curiosity, and willingness to explore subjects beyond the classroom. They also noted that AI tools reduce students' fear and anxiety toward learning, making the subject more engaging and learner-friendly. In addition, the findings agree with those of Nwafor and Tsakeni (2025), who reported strong agreement that AI supports Chemistry research and data analysis for both students and lecturers. This suggests that AI tools are valuable for designing experiments, visualizing chemical processes, and facilitating data-driven scientific investigations.

### **3.3. Recommendations**

- a. Institution should collaborate with industry experts to develop a curriculum that incorporates practical applications of artificial intelligence.
- b. Lecturers should undergo professional development training focused on the latest advancements in AI to enhance their teaching effectiveness
- c. Educational policymakers should allocate funding for AI research initiatives and infrastructure improvements within science education departments, Chemistry education inclusive.
- d. Institutions should establish partnerships with technology companies to provide students with internship opportunities that focus on AI projects.

### **4. Conclusion**

This study concludes that the extent of artificial intelligence (AI) integration in the teaching and learning of Chemistry in Colleges of Education in South-East Nigeria is still at a moderate level. Both lecturers and students share similar perceptions regarding the current state of AI adoption, indicating that while awareness and acceptance of AI are increasing, its practical implementation remains at a developing stage. The moderate level of integration is largely attributed to challenges such as inadequate infrastructure, limited access to AI tools and resources, insufficient training of lecturers and students, curriculum constraints, high cost of AI technologies, and limited understanding of ethical issues related to AI. Although, the study reveals a generally positive perception of the benefits of AI in Chemistry education. Respondents acknowledged that AI enhances students' understanding of complex concepts, improves academic performance, promotes individualized learning, strengthens problem-solving and critical thinking skills, and increases

motivation and curiosity. AI was also perceived as a valuable tool for supporting research, data analysis, experiment design, and visualization of chemical processes.

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All authors have equal contributions to the paper. All the authors have read and approved the final manuscript.

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