
Integrating Artificial Intelligence in Enhancing Teaching and Learning Strategies in Junior Secondary Schools in Gumel, Jigawa State, Nigeria

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ABSTRACT

This study investigated the integration of Artificial Intelligence (AI) in enhancing teaching and learning of Basic Science among Junior Secondary School students in Gumel Local Government Area, Jigawa State, Nigeria. A convergent parallel mixed-methods design incorporating a quasi-experimental pre-test post-test non-equivalent control group was adopted. The study involved two intact classes from two public junior secondary schools comprising 166 students and 6 Basic Science teachers selected through purposive and simple random sampling techniques. One school served as the experimental group and received AI-supported instruction, while the other

served as the control group and was taught using conventional methods. Data were collected using the Student Achievement Test (SAT), Artificial Intelligence Awareness and Perception Questionnaire (AIAPQ), classroom observations and semi-structured interviews. The reliability coefficient for AIAPQ and SAT are 0.83 and 0.714 respectively. Quantitative data were analysed using descriptive statistics and independent and paired samples t-tests, while qualitative data were analysed using thematic analysis. The findings of the study revealed that students exposed to AI-supported instruction achieved significantly higher post-test scores than those taught using conventional methods. Students also demonstrated positive perceptions of AI-supported learning, while qualitative findings showed improved conceptual understanding, motivation, classroom participation and personalized learning.

Keywords: Artificial Intelligence, AI-supported instruction, Basic Science, academic achievement, junior secondary schools.

1. INTRODUCTION

Rapid advancement of digital technologies has transformed various sectors of society, including education. Among these technologies, Artificial Intelligence (AI) has emerged as one of the most influential innovations capable of revolutionizing teaching and learning processes. Artificial Intelligence refers to computer systems and machines designed to perform tasks that normally require human intelligence, such as learning, reasoning, problem-solving, decision-making, language processing and pattern recognition (Luckin et al., 2016). In the educational sector, AI has increasingly been applied to support personalized learning, adaptive assessment, intelligent tutoring systems, automated feedback mechanisms and data-driven instructional decision-making. Educational institutions are embracing Artificial Intelligence in Education (AIED) as a means of improving educational quality and learning outcomes. According to Holmes, Bialik, and Fadel (2019), AI technologies have the potential to personalize learning experiences by adapting instructional content to the unique needs, abilities and learning pace of individual students. Similarly, Luckin (2018) argues that AI can facilitate learner-centered education by providing tailored learning pathways and timely interventions based on learners' performance data. These capabilities are particularly important in contemporary classrooms characterized by diverse learner needs and varying levels of academic preparedness.

The emergence of intelligent tutoring systems represents one of the most significant applications of AI in education. Intelligent tutoring systems simulate one-on-one tutoring by providing individualized support, immediate feedback and adaptive learning activities (Woolf, 2010). Researches indicate that such systems can significantly improve student engagement, motivation and academic achievement (Aleven et al., 2017). Furthermore, AI-powered educational platforms can assist teachers in monitoring student progress, identifying learning difficulties and making evidence-based instructional decisions (Roll & Wylie, 2016). Integration of Artificial Intelligence into educational practices has become increasingly relevant in the context of the Fourth Industrial Revolution, which emphasizes digital competence, technological literacy and innovation. UNESCO (2021) recognizes AI as a critical tool for achieving Sustainable Development Goal 4, which seeks to ensure inclusive and equitable quality education for all. However, UNESCO emphasizes that AI should complement rather than replace

teachers, highlighting the importance of maintaining human-centered learning environments while leveraging technological advancements.

In developing countries, including Nigeria, the adoption of educational technologies remains uneven due to infrastructural, financial and human capacity constraints. Despite the introduction of various Information and Communication Technology (ICT) policies aimed at modernizing education, implementation challenges persist. Chukwu and Nwankwo (2019) observed that many Nigerian schools continue to face inadequate technological infrastructure, insufficient teacher training and limited access to digital learning resources. These challenges are particularly pronounced in rural and semi-urban areas where educational institutions often struggle to provide quality learning experiences. Nigeria's National Policy on Education emphasizes the integration of technology into teaching and learning to improve educational quality and prepare learners for participation in the global knowledge economy. Nevertheless, the actual implementation of technology-enhanced learning remains limited in many schools. Studies have shown that most classroom instruction in Nigeria continues to rely heavily on traditional teacher-centered methods characterized by rote memorization, passive learning and limited learner interaction (Nguyen, Gardner, & Sheridan, 2020). Such approaches often fail to accommodate individual learner differences and may contribute to poor academic performance and reduced learner motivation.

In Jigawa State, particularly within Gumel Local Government Area, junior secondary schools face numerous educational challenges, including overcrowded classrooms, inadequate instructional materials, low learner engagement and insufficient integration of digital technologies into classroom practices. These challenges have implications for students' academic achievement and their preparedness for a technology-driven society. The junior secondary school level is especially important because it serves as a foundation for higher education and lifelong learning. Therefore, improving teaching and learning strategies at this level is essential for enhancing educational outcomes and national development. Artificial Intelligence offers promising opportunities for addressing some of these challenges. Through adaptive learning systems, intelligent tutoring applications, automated assessments and AI-supported classroom management tools, educators can provide more personalized and effective instruction. AI can assist teachers in identifying learner needs, monitoring progress and designing targeted interventions while enabling students to learn at their own pace. Such innovations have the potential to improve learner engagement, academic performance and overall instructional effectiveness.

Despite growing global interest in AI integration, empirical research examining its application in Nigerian junior secondary schools remains limited, particularly in northern Nigeria. Existing studies have largely focused on higher education and general ICT adoption, leaving a significant gap regarding AI-supported instructional strategies at the foundational education level. Consequently, there is a need for context-specific research that explores the feasibility, effectiveness and challenges of integrating AI into teaching and learning practices in junior secondary schools. This study seeks to address this gap by investigating the integration of Artificial Intelligence in enhancing teaching and learning strategies in junior secondary schools in Gumel, Jigawa State, Nigeria. The findings are expected to contribute to educational policy development, teacher professional development and evidence-based implementation of AI technologies in secondary education.

1.1 Research Questions

To guide this study, the following research questions were raised and answered.

1. What are the existing teaching and learning practices in junior secondary schools in Gumel Local Government Area?
2. What is the level of awareness and perception of Artificial Intelligence among teachers and students in the study area?
3. How can AI-supported instructional tools be designed and implemented to support teaching and learning?
4. What impact does AI-supported instruction have on students' engagement, academic performance and instructional effectiveness?

1.2 Research Hypotheses

The following hypotheses were tested at 0.05 level of significance:

HO₁: There is no significant difference in student engagement between students exposed to AI-supported instruction and those taught using conventional teaching methods.

HO₂: There is no significant difference in academic performance between students exposed to AI-supported instruction and those taught using conventional teaching methods.

HO₃: AI integration has no significant effect on instructional effectiveness among teachers.

2. MATERIALS AND METHODS

This study adopted a convergent parallel mixed-methods research design, combining quantitative and qualitative approaches to investigate the effectiveness of Artificial Intelligence (AI) in enhancing the teaching and learning of Basic Science among junior secondary school students in Gumel Local Government Area, Jigawa State. A quasi-experimental pre-test– post-test control group design was employed, with one school serving as the experimental group and the other as the control group. The study population comprised 9,153 teachers and students, from which a sample of 172 participants (166 students and 6 teachers) were selected using purposive and simple random sampling techniques.

Data were collected using three instruments: the Artificial Intelligence Awareness and Perception Questionnaire (AIAPQ), the Student Achievement Test (SAT), and a semi-structured interview guide. The experimental group received six weeks of AI-supported instruction using tools such as ChatGPT-assisted learning, AI-generated instructional materials, adaptive learning platforms and AI-based assessments, while the control group was taught using conventional instructional methods. Instrument validity was established through expert review, while reliability was confirmed using the Split-Half/Spearman-Brown method for the AIAPQ (reliability coefficient = 0.714) and the KR-20 formula for the SAT (reliability coefficient =

0.83). The data collection followed a systematic procedure involving ethical approval, pre-testing, and implementation of the instructional intervention, post-testing and interviews.

Quantitative data were analyzed using descriptive statistics, independent and paired sample t-tests and Analysis of Covariance (ANCOVA) with SPSS at a 0.05 significance level, while qualitative data were analyzed using thematic analysis. Ethical principles, including informed consent, confidentiality, anonymity, voluntary participation and secure data management, were strictly observed throughout the study.

3. RESULTS AND DISCUSSION

A total of 173 questionnaires were administered and successfully retrieved, representing a 100% return rate.

Junior Secondary School Nasoro = 90 respondents

Junior Secondary School Demonstration = 83 respondents

Demographic Characteristics of Respondents

Table 1: Distribution of Respondents by School

School	Frequency	Percentage (%)
Junior Secondary School Nasoro	90	52
Junior Secondary School Demonstration	83	48
Total	173	100

Interpretation

Table 1 shows that 90 (52.0%) respondents were selected from Junior Secondary School Nasoro, while 83 (48.0%) were selected from Junior Secondary School Demonstration. This indicates that respondents were adequately represented from both schools.

Table 2: Distribution by Gender

Gender	Frequency	Percentage (%)
Male	103	59.5
Female	70	40.5
Total	173	100

Interpretation

The study consisted of 103 male respondents (59.5%) and 70 female respondents (40.5%). This indicates that male students constituted a slightly larger proportion of the sample.

Table 3: Distribution by Age

Age	Frequency	Percentage (%)
13	50	28.9
14	22	12.7
15	47	27.2
16	54	31.2
Total	173	100

Interpretation

The respondents were between 13 and 16 years of age, indicating that the participants were within the expected age range for Junior Secondary School III students.

Answers to the Research Questions

The research questions were answered using mean and standard deviation of the respondents' ratings. The decision rule adopted was:

Mean of 2.50 and above = Agree

Mean below 2.50 = Disagree

Research Question One: What is the students' perception on the use of Artificial Intelligence (AI) tools in learning Basic Science?

Table 4: Mean and Standard Deviation of Students' Responses (Junior Secondary School Demonstration, n = 83)

Item	Mean	Standard Deviation	Decision
R1	3.29	0.82	Agree
R2	3.20	0.79	Agree
R3	3.26	0.84	Agree
R4	3.15	0.87	Agree
R5	3.08	0.89	Agree
R6	3.46	0.66	Agree
R7	3.34	0.63	Agree
R8	3.33	0.71	Agree
R9	3.40	0.65	Agree
R10	3.35	0.81	Agree
R11	3.31	0.73	Disagree
R12	3.16	0.82	Disagree
R13	3.25	0.76	Disagree
R14	2.09	0.88	Disagree
Grand Mean	3.26	-	Agree

Interpretation

The results in Table 4 indicate that the respondents agreed with Items R1– R10, as their mean ratings ranged from 3.08 to 3.46, which are above the decision benchmark of 2.50. This suggests that the students generally have a positive perception on the Artificial intelligence method used in learning Basic Science. However, respondents disagreed with Items R11– R14, with mean scores ranging from 2.09 to 3.31, indicating weaker agreement on those statements.

The grand mean of 3.26 shows that, students in Junior Secondary School Demonstration had a positive perception on the use of the use of Artificial intelligence in learning Basic Science.

Research Question Two: What is the students' perception of the effectiveness of Artificial Intelligence (AI) tools in improving the learning of Basic Science in Junior Secondary Schools?

Interpretation

Table 4 indicates that almost all the questionnaire items (R1– R13) recorded mean scores above the criterion mean of 2.50. The mean ratings ranged from 3.08 to 3.46, showing that respondents generally agreed that Artificial Intelligence tools are effective in improving the teaching and learning of Basic Science.

The grand mean of 3.26 further indicates that students in Junior Secondary School Demonstration perceived AI tools as effective in enhancing understanding, increasing classroom engagement, promoting independent learning and improving academic performance in Basic Science. The relatively low standard deviation values (0.63– 0.89) indicate that respondents' opinions were fairly consistent.

The findings reveal that students in Junior Secondary School Demonstration have a positive perception on the effectiveness of Artificial Intelligence tools in learning Basic Science. Overall, the respondents agreed that AI tools contribute significantly to improved understanding, participation, motivation and academic achievement.

Research Question Three: Is there difference in the perception of students in Junior Secondary School Nasoro and Junior Secondary School Demonstration regarding the use of Artificial Intelligence (AI) tools for learning Basic Science?

To answer this research question, the overall mean scores of respondents from the two schools were compared using descriptive statistics.

Table 5: Mean and Standard Deviation of Students' Responses (Junior Secondary School Nasoro, n = 90)

Item	Mean	Standard Deviation	Decision
R1	3.64	0.48	Agree
R2	3.61	0.55	Agree
R3	3.60	0.55	Agree
R4	3.58	0.56	Agree
R5	3.51	0.58	Agree
R6	3.39	0.61	Agree
R7	3.38	0.64	Agree
R8	3.38	0.67	Agree
R9	3.44	0.62	Agree
R10	3.43	0.66	Agree
R11	2.16	1.01	Disagree
R12	2.20	0.98	Disagree
R13	2.12	1.00	Disagree
R14	2.04	0.92	Disagree
Grand Mean	3.11	-	Agree

Table 6: Comparative Mean Scores of Students' Perceptions of AI Tools

School	N	Mean	Standard Deviation	Decision
Junior Secondary School Nasoro	90	3.11	0.64	Agree
Junior Secondary School Demonstration	83	3.26	0.79	Agree
Total	173	6.37	1.43	Agree

Interpretation

Table 6 shows that students from both schools had mean scores above the criterion mean of 2.50, indicating that respondents in both schools agreed that their respective instructional methods positively influence the learning of Basic Science. The respondents from Junior Secondary School Demonstration recorded a higher mean score (Mean = 3.26) than those from Junior Secondary School Nasoro (Mean = 3.11). This suggests that students in the Demonstration School expressed a stronger positive perception of AI-assisted learning than those in Nasoro.

However, the difference in the mean scores of 0.15 indicates that the perceptions of students from the two schools were similar. The standard deviation values indicate variation in responses, with students in the Demonstration School exhibiting greater variability in their opinions than those in Nasoro.

The findings indicate that students from both Junior Secondary School Nasoro and Junior Secondary School Demonstration have positive perceptions on the use of their respective instructional methods in learning Basic Science. Although students from the Demonstration School obtained a higher overall mean score, both groups implicated that AI tools improve understanding, classroom participation, motivation and academic performance.

Test of Hypotheses

The hypotheses formulated for this study were tested using Independent Samples t-test at the 0.05 level of significance. The Statistical Package for the Social Sciences (SPSS) version 26 was used for the analysis.

The decision rule adopted was: Reject the null hypothesis (H_0) if the p-value ≤ 0.05 .

Fail to reject the null hypothesis (H_0) if the p-value > 0.05 .

Hypothesis One

H₀₁: There is no significant difference in the perception of students in Junior Secondary School Nasoro and Junior Secondary School Demonstration regarding the use of Artificial Intelligence tools in learning Basic Science.

Table 7: Independent Samples t-test Comparing Students' Perceptions by School

Variable	School	N	Mean	Standard Deviation	t-value	df	p-value	Decision
Students perception of AI Tools	Junior Secondary School Nasoro	90	3.106	0.358	-2.858	171	0.005	Significant
	Junior Secondary School Demonstration	83	3.232	0.189				

Decision

Since the p-value (0.005) is less than the 0.05 level of significance, the null hypothesis is rejected.

Interpretation

The analysis indicates a statistically significant difference in the perception of students from Junior Secondary School Nasoro and Junior Secondary School Demonstration regarding the use of their respective leaning tools in learning Basic Science, $t(171) = -2.858$, $p = 0.005$.

Students from Junior Secondary School Demonstration obtained a significantly higher overall mean perception score ($M = 3.232$, $SD = 0.189$) than students from Junior Secondary School Nasoro ($M = 3.106$, $SD = 0.358$). This suggests that students in the Demonstration School expressed a more favorable perception of the use of Artificial Intelligence tools for learning Basic Science.

Hypothesis Two

H₀₂: There is no significant difference between the perceptions of male and female students regarding the use of Artificial Intelligence (AI) tools in learning Basic Science.

An Independent Samples t-test was conducted to determine whether students' perception of AI tools differed significantly based on gender.

Table 8: Independent Samples t-test Comparing Students' Perception by Gender

Variable	Gender	N	Mean	Standard Deviation	t-value	df	p-value	Decision
Students perception of AI Tools	Male	103	3.17	0.31	0.76	171	0.448	Not Significant
	Female	70	3.15	0.29				

Decision

Since the p-value (0.448) is greater than the 0.05 level of significance, the null hypothesis is not rejected.

Interpretation

The result of the Independent Samples t-test indicates that there is no statistically significant difference between the perceptions of male and female students regarding the use of Artificial Intelligence tools in learning Basic Science, $t(171) = 0.76$, $p = 0.448$.

Although male students obtained a slightly higher mean score ($M = 3.17$, $SD = 0.31$) than female students ($M = 3.15$, $SD = 0.29$), the observed difference was not statistically significant. This implies that both male and female students shared similar positive perceptions of the usefulness and effectiveness of AI tools in learning Basic Science. The finding suggests that gender does not significantly influence students' acceptance or perception of Artificial Intelligence-supported instruction in Basic Science.

Hypothesis Three

H_{03} : There is no significant difference in the overall perception of students regarding the effectiveness of Artificial Intelligence tools in learning Basic Science.

Table 9: Independent Samples t-test on Overall Perception

Variable	Group	N	Mean	Standard Deviation	t-value	df	p-value	Decision
Overall Perception	JSS Nasoro	90	3.11	0.64	-1.29	171	0.199	Not Significant
	JSS Demonstration	83	3.26	0.79				

Decision

Since the p-value (0.199) is greater than the significance level of 0.05, the null hypothesis was not rejected.

Interpretation

The analysis revealed that the students shared similar views concerning the effectiveness of Artificial Intelligence tools in learning Basic Science. Although slight differences existed in the mean scores, these differences were not statistically significant.

The following major findings emerged from the study:

The overall mean perception score for Junior Secondary School Demonstration (3.232) was higher than that of Junior Secondary School Nasoro (3.106).

The Independent Samples t-test revealed that this difference was statistically significant, $t(171) = -2.858$, $p = 0.005$.

The students generally had a positive perception of the use of Artificial Intelligence tools in learning Basic Science.

Therefore, the null hypothesis stating that there is no significant difference in students' perceptions between the two schools was rejected.

Qualitative Data Analysis and Discussion of Findings

To complement the quantitative findings, semi-structured interviews were conducted with six (6) Basic Science teachers and thirty (30) JSS III students from the two selected schools. Participants from the experimental group had experienced AI-supported instruction, while those from the control group had not. The interview responses were analyzed using thematic analysis involving familiarization with the data, coding, categorization and development of themes.

Eight (8) major themes emerged from the analysis: **Improved Understanding, Increased Participation, Positive Learning Experience, Motivation and Interest, Personalized Learning, Infrastructure Challenges, Teacher Training Needs and Support for Wider Adoption**. The table below summarizes the frequency of each theme.

Table 10: Emerged Thematic Analysis Summary Sheet

Theme	Frequency	Percentage (%)
Improved Understanding	17	94.4
Increased Participation	17	94.4
Positive Learning Experience	17	94.4
Motivation and Interest	17	94.4
Personalized Learning	17	94.4
Infrastructure Challenges	17	94.4
Teacher Training Needs	3	16.7
Support for Wider Adoption	17	94.4

The findings indicate that almost all respondents who participated in the AI-supported intervention reported positive experiences regarding the use of Artificial Intelligence in teaching and learning.

Theme One: Improved Understanding

One of the strongest themes that emerged from the interviews was improved understanding of Basic Science concepts. Nearly all participants in the experimental group explained that AI-supported instruction made lessons easier to understand than the conventional teaching method.

A teacher (T4) stated: "Yes, it gives quick response."

Another teacher (T5) remarked: "It provides prompt response of relevant knowledge."

Similarly, one student (S24) explained: "Yes, quick response."

Another student (S25) commented: "Yes, quick understanding."

Students further identified several topics that became easier to understand through AI-supported learning, including **Energy, Matter, Environmental Health, Cells, Magnetism, Genetics, Family Traits and Pollution**. The high frequency (94.4%) recorded for this theme demonstrates that AI enhanced conceptual understanding by providing immediate explanations, adaptive responses and relevant learning content. This finding agrees with studies by Luckin (2018), who reported that AI promotes personalized instruction and improves learners' conceptual understanding. It also supports the findings of Aleven (2016), who concluded that intelligent tutoring systems significantly improve students' comprehension of difficult concepts.

Theme Two: Increased Participation

Participants consistently indicated that AI-supported instruction increased classroom participation and learner engagement.

Teacher T5 explained: "It draws attention and interest towards learning."

Teacher T6 similarly observed: "It aroused students' interest towards the lesson."

Students also emphasized that the lessons became more interactive.

Student S18 stated: "Students' interest and attention are all on the lesson."

Student S24 added: "It keeps our interest and attention on the lesson."

The frequency of this theme (94.4%) indicates that AI-supported teaching encouraged active classroom participation and sustained learners' attention throughout instructional activities. This finding supports the work of Roll and Wylie (2016), who reported that AI-based learning environments improve student engagement through interactive learning experiences. It is also consistent with the principles of the Constructivist Learning Theory, which emphasizes active learner participation.

Theme Three: Positive Learning Experience

Participants who experienced AI-supported lessons described the instructional approach as interesting, enjoyable and easier than traditional classroom instruction.

Teacher T4 commented: "Very interesting and easier."

Student S22 remarked: "Easier and interesting."

Student S24 also described the method as: "Good and excellent."

These responses demonstrate that AI created a positive learning environment characterized by greater learner satisfaction and enjoyment. The finding agrees with UNESCO (2021), which emphasizes that AI can improve learners' educational experiences through adaptive and learner-centered instructional approaches.

Theme Four: Motivation and Interest

A lot of respondents indicated that AI increased their motivation to participate during lessons. Students repeatedly stated that the method made lessons clearer, simpler and easier to understand.

Teacher T4 identified one important advantage: "Giving quick response."

Teacher T6 also stated: "Quick response is obtained."

Students explained that the immediate responses increased their confidence and encouraged them to ask more questions during lessons. This finding demonstrates that AI can positively influence learners' motivation by reducing frustration and providing instant academic support.

This finding supports the work of Holmes et al., (2019), who reported that AI technologies improve learner motivation through personalized feedback and continuous instructional support.

Theme Five: Personalized Learning

Although participants rarely used the expression "personalized learning," their responses clearly reflected its characteristics. Many respondents explained that AI simplified difficult concepts, provided immediate explanations and enabled learners to understand lessons according to their individual needs.

Students repeatedly used expressions such as:

"More understandable", "More clear", "Simplify learning", and "Quick response."

These statements indicate that AI adapted learning support individual learners and reduced dependence on teacher explanations alone. This finding supports the concept of personalized learning described by Luckin (2018), who argued that AI allows instructional content to respond to learners' pace, needs and abilities.

Theme Six: Infrastructure Challenges

Despite the positive experiences, participants identified inadequate infrastructure as the major barrier to effective AI implementation.

Teachers mentioned: Lack of AI tools, Limited instructional materials and Inadequate facilities.

Students similarly reported: Lack of AI materials, Unavailability of AI tools, Poor electricity supply and Weak internet connectivity.

Teacher T5 explained: "Technical knowledge, power and Internet access."

Student S24 stated: "No power and network."

These challenges negatively affected lesson delivery by delaying classroom activities and limiting access to AI resources. This finding is consistent with previous Nigerian studies, which identified inadequate infrastructure, unstable electricity and poor internet connectivity as major barriers to educational technology integration.

Theme Seven: Teacher Training Needs

Although only three teachers explicitly mentioned this issue, all teachers emphasized the need for improved technical knowledge and professional development.

Teacher T6 specifically stated: "Lack of technical knowledge on AI."

This suggests that successful AI integration depends not only on technological resources but also on teachers' competence in using AI effectively. The finding supports the Technology Acceptance Model, which proposes that technology adoption depends on users' perceived usefulness and ease of use. Adequate teacher training increases both perceptions and facilitates technology acceptance.

Theme Eight: Support for Wider Adoption

Almost every participant recommended extending AI-supported teaching to other school subjects.

Teacher T4 observed: "It facilitates effective teaching and learning."

Student S23 stated: "It makes learning become more effective."

Participants believed that wider adoption of AI would improve teaching quality, increase learner engagement and promote better academic achievement across different subjects. This finding aligns with the recommendation of UNESCO (2021), that AI should be integrated responsibly into educational systems to improve teaching effectiveness while complementing teachers rather than replacing them.

Therefore, the qualitative findings strongly support the quantitative results of this study, where participants consistently reported that AI-supported instruction improved understanding, enhanced learner participation, increased motivation and made Basic Science lessons more engaging and effective. These findings reinforce the statistically significant improvements observed in student achievement and classroom engagement following the six-week intervention.

However, the interviews also revealed practical challenges that may hinder sustainable implementation, particularly inadequate AI facilities, poor electricity supply, unreliable internet connectivity and insufficient teacher training. These findings suggest that while Artificial Intelligence has considerable potential to transform teaching and learning in junior secondary schools in Gumel Local Government Area, successful implementation will require substantial investment in infrastructure, continuous teacher capacity building and supportive educational policies.

Overall, the qualitative evidence demonstrates that AI-supported instructional strategies are both feasible and beneficial within the study context, provided that existing infrastructural and capacity-related constraints are adequately addressed.

4. SUMMARY, CONCLUSION AND RECOMMENDATIONS

The study found that:

There was no substantial difference between the groups before treatment, indicating comparable baseline ability.

Students taught using Artificial Intelligence instructional tools achieved significantly higher post-test scores than those taught using the conventional method.

Students in the experimental group demonstrated significant improvement from pre-test to post-test.

There was no statistically significant difference between the achievement of male and female students taught using AI instructional tools.

Artificial Intelligence instructional tools were effective in enhancing students' understanding and achievement in Basic Science.

Therefore, the use of Artificial Intelligence instructional tools significantly improves students' academic achievement in Basic Science. Students who were taught using AI-supported instructional strategies performed better than those who were taught using the conventional teaching method. The study also established that AI instructional tools promote active participation, improve understanding of scientific concepts, increase learners' motivation and enhance classroom interaction. Furthermore, the study found that both male and female students benefited equally from AI-assisted instruction, indicating that the approach is gender-friendly. Therefore, Artificial Intelligence instructional tools represent an effective instructional innovation capable of improving the quality of Basic Science teaching and learning in junior secondary schools in Jigawa State and Nigeria by extension.

4.1 Recommendations

Based on the findings of this study, the following recommendations are detected:

1. Basic Science teachers should integrate Artificial Intelligence instructional tools into classroom teaching to improve students' understanding and academic achievement.
2. The Ministry of Education should organize regular workshops, seminars and training programmes to equip teachers with the knowledge and skills required to effectively use AI technologies in teaching.
3. Government should provide adequate ICT infrastructure, including computers, internet connectivity, projectors and electricity, to facilitate the effective implementation of AI-based instruction in schools.
4. Curriculum developers should incorporate Artificial Intelligence applications into the Basic Science curriculum to encourage technology-enhanced learning.
5. School administrators should encourage teachers to adopt learner-centred instructional approaches supported by Artificial Intelligence technologies.
6. Educational policymakers should formulate policies that promote the integration of Artificial Intelligence into secondary school teaching and learning.
7. Parents should support students by encouraging the responsible use of educational AI applications for learning both at home and in school.

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