INFLUENCE OF TEACHERS' KNOWLEDGE AND COMPETENCE IN USING ARTIFICIAL INTELLIGENCE TOOLS FOR STEM INSTRUCTION IN FAGGE EDUCATION ZONE, KANO STATE, NIGERIA

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Abstract
This study explored influence of teachers' knowledge and competence in using artificial intelligence tools for stem instruction in Fagge Education Zone, Kano State, Nigeria. Three objectives and research questions guided the study. A descriptive survey design was adopted, involving a population of 214 STEM teachers, from which 140 were selected through stratified random sampling. Data were collected using Teachers Knowledge Competency Questionnaire (TKCQ) with a reliability coefficient of 0.72 using Cronbach alpha, aligned with research questions on teachers' knowledge, competence, and challenges in AI integration. Descriptive statistics, including frequencies, percentages, and mean scores, were used for analysis. Findings revealed that teachers demonstrated a moderate level of knowledge and competence, showing awareness of AI concepts and familiarity with instructional tools but limited practical application in lesson planning, assessment, and classroom implementation. Major challenges identified included inadequate training, limited digital resources, insufficient technical support, and infrastructural deficits. The study concludes that strengthening teacher capacity and institutional support is critical for effective AI integration in Nigerian STEM education. The study recommended that; government should organize continuous training workshops and seminars to enhance STEM teachers' knowledge and competence in AI tools among others.
Keywords: Teachers' Competence, Artificial Intelligence, STEM Instruction.

Introduction
The rapid advancement of Artificial Intelligence (AI) technologies has created transformative opportunities for enhancing teaching and learning processes worldwide. In Science, Technology, Engineering, and Mathematics (STEM) education, AI offers powerful tools capable of supporting personalized learning, simulating complex scientific phenomena, analyzing large datasets in real time, and providing immediate formative feedback to learners (Baah et al, 2024; Guo, Wang, & Li, 2025). These capabilities align strongly with the goals of STEM education, which emphasize inquiry, experimentation, analytical reasoning, and problem-solving skills.

In STEM subjects particularly, AI-powered simulations allow students to manipulate variables in virtual laboratories, model engineering systems, and visualize molecular or environmental processes that are otherwise difficult to observe physically (Solé, et al., 2023; Pozo Muñoz et al., 2023). Such innovations have been associated with increased engagement, deeper conceptual understanding, and improved retention of knowledge. However, the success of these technologies depends not merely on their availability but on the ability of teachers to integrate them meaningfully into pedagogical practice. Although AI tools may be advanced, their educational effectiveness depends on teachers' ability to design meaningful learning experiences, interpret AI-generated data, and align these tools with curriculum goals. Thus, teachers' knowledge and competence in using AI are critical to instructional quality (Bolaji et al., 2025). Without adequate understanding of AI functionalities and pedagogical applications, these tools risk being underutilized or applied superficially rather than serving as transformative resources in the classroom.

In Nigeria, the integration of AI in secondary education remains limited and inconsistent. Despite growing awareness of digital technologies, many schools continue to rely on traditional, lecture-based teaching with minimal technological use. Effective AI adoption requires both adequate infrastructure and teacher preparedness. Although some teachers are familiar with general digital tools, exposure to AI-specific applications in STEM instruction is still minimal (Agyekum et al., 2025). As a result, the potential of AI to significantly improve STEM education in Nigeria has yet to be fully realized. Teachers' knowledge of AI encompasses both conceptual understanding and practical skills. Conceptually, teachers need to understand AI principles, including how algorithms function and how systems generate predictions or feedback. Practically, they must be able to use AI tools effectively, design AI-supported lessons, and critically evaluate AI outputs (Sinatra et al., 2022). This knowledge goes beyond technical familiarity to include pedagogical judgment, ethical considerations, and alignment with instructional goals. Without such multidimensional competence, meaningful AI integration that enhances student learning may be difficult to achieve.

Research shows that while many educators worldwide have moderate awareness of AI technologies, they often lack the deeper pedagogical understanding required for meaningful integration (Kumari & Suman, 2025). This gap is especially critical in STEM education, where AI tools are complex and demand specialized knowledge. Effectively using AI-driven simulations in subjects like physics or chemistry requires not only technical skills but also strong subject expertise and sound pedagogical judgment. Teachers must know when and how to apply AI tools, guide students' interactions with them, and interpret the learning data generated to support instruction.

Competence, therefore, refers to the ability to apply AI tools effectively to achieve specific instructional objectives. It includes planning AI-supported lessons, facilitating interactive learning environments, using AI for formative and summative assessment, and adapting instruction based on AI-generated insights (Guo, Wang, & Li, 2025). Competence also

involves troubleshooting technical issues, ensuring ethical use of AI systems, and maintaining learner autonomy in AI-enhanced environments. In many contexts, inadequate professional training and limited access to AI infrastructure significantly hinder the development of such competence (Obodo & Ani, 2025). Teachers may feel uncertain about integrating AI tools due to lack of institutional support, insufficient training workshops, or limited opportunities for hands-on practice. Nigeria's education system faces infrastructural and systemic challenges that hinder effective AI integration in schools. Persistent issues such as unreliable electricity, limited internet access, inadequate digital devices, and insufficient teacher training restrict meaningful technology adoption (Akin Olayemi & Idris Tajudeen, 2025; Awofala et al., 2025). Weak policy alignment and limited professional development further reduce teachers' capacity to use AI tools effectively (Olawunmi, 2025). In response, this study investigates teachers' knowledge and competence in using AI tools for STEM instruction in Fagge Education Zone, Kano, Nigeria.

Statement of the Problem

Artificial Intelligence (AI) is transforming education through personalized learning and automated assessment, but its effective classroom use depends on teachers' knowledge, skills, and preparedness (Traga-Philippakos et al., 2025; Sperling, 2024). In Nigeria, although secondary school teachers show moderate awareness of AI (David et al., 2025; Okafor & Anyanwu, 2025; Maruf et al., 2025), their practical competence in applying AI for STEM instruction remains underexplored. Infrastructural challenges and limited professional development further restrict meaningful integration. Therefore, this study examines teachers' knowledge and competence in using AI tools for STEM instruction in Fagge Education Zone, Kano, Nigeria.

Objectives of the Study

The main objective of this study is to investigate the Influence of Teachers' Knowledge and Competence in Using Artificial Intelligence Tools for STEM Instruction in Fagge Education Zone, Kano, Nigeria. Specifically, the study sort to:

1. assess teachers' knowledge of AI tools for STEM instruction in Fagge Education Zone, Kano State, Nigeria.
2. evaluate teachers' competence in integrating AI tools into STEM teaching in Fagge Education Zone, Kano State, Nigeria
3. identify challenges hindering effective AI integration in Nigerian STEM classrooms in Fagge Education Zone, Kano State, Nigeria.

Research Questions

The following research questions were formulated and answered:

1. What is the level of knowledge of Nigerian STEM teachers regarding AI tools for instruction in Fagge Education Zone, Kano State, Nigeria?
2. What is the level of competence of teachers in using AI tools for STEM teaching in in Fagge Education Zone, Kano State, Nigeria?

3. What challenges do teachers face in integrating AI tools into STEM instruction in Fagge Education Zone, Kano State, Nigeria?

Methodology

This study adopted a descriptive survey research design. The descriptive survey design was considered appropriate because the study sought to systematically describe and assess teachers' knowledge and competence in using Artificial Intelligence (AI) tools for STEM instruction without manipulating any variables. The design enabled the researcher to collect data from STEM teachers within their natural school environment and to examine existing conditions regarding AI awareness, instructional competence, and integration challenges in public secondary schools in Fagge Education Zone, Kano State, Nigeria. The population of the study comprised all STEM teachers in public secondary schools in Fagge Education Zone, Kano State, Nigeria. STEM teachers include teachers of Mathematics, Biology, Chemistry, Physics, Basic Science, and Computer Science at both junior and senior secondary school levels. Records obtained from the Fagge Zonal Education Office indicated that there are 214 STEM teachers across public secondary schools in the zone. These 214 teachers constituted the target population for the study because they are directly responsible for delivering STEM instruction and are central to the successful integration of AI tools in classroom practice. From the total population of 214 STEM teachers, a sample size of 140 teachers was determined using the Yamane (1967) formula for sample size determination at a 5% level of precision. A stratified random sampling technique was employed to ensure adequate representation of different STEM subject areas within public secondary schools. The teachers were first grouped based on subject specialization (Mathematics, Biology, Chemistry, Physics, Basic Science, and Computer Science). Thereafter, proportional sampling was used to select respondents from each subject area. Simple random sampling was then applied within each stratum to select the participating teachers.

Data were collected using Teachers Knowledge Competency Questionnaire (TKCQ) which was validated by experts in Educational Technology, Science Education, and Measurement and Evaluation. A pilot test was conducted using STEM teachers from a public secondary school outside Fagge Education Zone but within Kano State. The reliability of coefficient of 0.72 was determined using Cronbach's Alpha. Data collected from the respondents were analyzed using descriptive statistics, including frequencies, percentages, means, and standard deviations.

Results

Research Question 1: What is the level of knowledge of Nigerian STEM teachers regarding AI tools for instruction in Fagge Education Zone, Kano State, Nigeria?

Table 1: Level of Knowledge of STEM Teachers Regarding AI Tools

Item	Questionnaire Item	SD	D	A	SA	Mean	Interpretation
1.	I am aware of what Artificial Intelligence (AI) is and its applications in teaching.	8 (5.7%)	22 (15.7%)	70 (50.0%)	40 (28.6%)	3.02	Moderate Knowledge
2.	I am familiar with AI tools commonly used for teaching STEM subjects	12 (8.6%)	36 (25.7%)	62 (44.3%)	30 (21.4%)	2.80	Moderate Knowledge
3.	I understand how AI tools can be used to enhance students' learning of STEM concepts.	15 (10.7%)	40 (28.6%)	58 (41.4%)	27 (19.3%)	2.75	Moderate Knowledge
4.	I can identify AI tools that are relevant for my STEM subject area.	10 (7.1%)	35 (25.0%)	65 (46.4%)	30 (21.5%)	2.86	Moderate Knowledge
5.	I am knowledgeable about how AI can provide personalized learning experiences to students.	18 (12.9%)	42 (30.0%)	55 (39.3%)	25 (17.8%)	2.72	Moderate Knowledge
6.	I am aware of AI tools that can assist in assessing students' understanding of STEM concepts.	13 (9.3%)	38 (27.1%)	61 (43.6%)	28 (20.0%)	2.84	Moderate Knowledge

7.	I understand the basic functioning of AI-driven educational platforms and simulations.	20 (14.3%)	45 (32.1%)	50 (35.7%)	25 (17.9%)	2.63	Moderate Knowledge
8.	I can explain to colleagues or students how AI tools support STEM instruction.	22 (15.7%)	48 (34.3%)	45 (32.1%)	25 (17.9%)	2.55	

The findings in table 1 indicates that, teachers demonstrated a moderate understanding of Artificial Intelligence (AI) tools for instruction. Teachers reported the highest level of knowledge for awareness of AI and its applications in teaching (M = 3.02), suggesting that most respondents recognize AI as a concept and are generally familiar with its educational potential. Teachers also displayed moderate familiarity with AI tools commonly used in STEM education, such as intelligent tutoring systems, adaptive learning platforms, and simulations (M = 2.80–2.86). Similarly, respondents indicated moderate understanding of how AI can be applied to enhance students' learning of STEM concepts (M = 2.75) and assist in assessing students' understanding (M = 2.84). These results suggest that while teachers are exposed to AI concepts, their practical knowledge of how to implement these tools in lesson planning, personalized learning, or formative assessment remains limited. Lower mean scores were observed for items related to explaining AI tools to colleagues or students (M = 2.55) and understanding the basic functioning of AI-driven educational platforms and simulations (M = 2.63). This indicates that although teachers have conceptual awareness, their operational knowledge and confidence in applying AI tools effectively in classroom practice are less developed.

Research Question Two: What is the level of competence of teachers in using AI tools for STEM teaching in Fagge Education Zone, Kano State, Nigeria?

Table 2: Level of Competence of STEM Teachers in Using AI Tools

Item	Questionnaire Item	SD	D	A	SA	Mean	Interpretation
1.	I am able to plan STEM lessons using AI	10 (7.1%)	28 (20.0%)	70 (50.0%)	32 (22.9%)	2.90	Moderate Competence

	tools effectively.						
2.	I can integrate AI tools to engage students actively in STEM lessons.	12 (8.6%)	35 (25.0%)	65 (46.4%)	28 (20.0%)	2.83	Moderate Competence
3.	I can use AI tools to provide personalized feedback to students.	18 (12.9%)	42 (30.0%)	56 (40.0%)	24 (17.1%)	2.72	Moderate Competence
4.	I am competent in using AI tools to assess students' understanding of STEM concepts.	14 (10.0%)	38 (27.1%)	60 (42.9%)	28 (20.0%)	2.81	Moderate Competence
5.	I can troubleshoot basic technical issues when using AI tools in the classroom.	22 (15.7%)	48 (34.3%)	46 (32.9%)	24 (17.1%)	2.52	Moderate Competence
6.	I can select appropriate AI tools that align with STEM curriculum objectives.	11 (7.9%)	36 (25.7%)	65 (46.4%)	28 (20.0%)	2.85	Moderate Competence
7.	I feel confident in applying AI tools to support	15 (10.7%)	40 (28.6%)	60 (42.9%)	25 (17.8%)	2.79	Moderate Competence

	in STEM subjects.						
8.	I can adapt AI tools to meet the diverse learning needs of students in my STEM classes.	20 (14.3%)	45 (32.1%)	50 (35.7%)	25 (17.9%)	2.55	Moderate Competence

The findings in table 2 indicate that STEM teachers in public secondary schools in Fagge Education Zone exhibited a moderate level of competence in using AI tools for instructional purposes. Teachers reported the highest proficiency in planning STEM lessons with AI tools (M = 2.90) and selecting appropriate AI tools that align with curriculum objectives (M = 2.85), suggesting reasonable capability in lesson preparation and tool selection. Moderate competence was also observed in integrating AI tools to actively engage students, assessing student understanding, and supporting collaborative learning. Teachers demonstrated lower confidence in troubleshooting technical issues (M = 2.52) and adapting AI tools to meet diverse student needs (M = 2.55), indicating areas where practical skills and self-efficacy are limited.

Research Question Three: What challenges do teachers face in integrating AI tools into STEM instruction in Fagge Education Zone, Kano State, Nigeria?

Table 3: Challenges of Integrating AI Tools in STEM Instruction

Item	Questionnaire Item	SD	D	A	SA	Mean	Interpretation
1.	Inadequate training limits my ability to use AI tools effectively.	5 (3.6%)	18 (12.9%)	70 (50.0%)	47 (33.6%)	3.13	High Challenge
2.	Lack of access to computers, internet, and other digital devices hinders AI integration.	4 (2.9%)	15 (10.7%)	60 (42.9%)	61 (43.5%)	3.26	High Challenge
3.	Insufficient technical support	6 (4.3%)	20 (14.3%)	62 (44.3%)	52 (37.1%)	3.15	High Challenge

	affects my use of AI tools.						
4.	Limited exposure to AI applications for STEM instruction affects my competence.	7 (5.0%)	22 (15.7%)	58 (41.4%)	53 (37.9%)	3.12	High Challenge
5.	Large class sizes make it difficult to apply AI tools effectively.	5 (3.6%)	30 (21.4%)	65 (46.4%)	40 (28.6%)	2.98	Moderate Challenge
6.	Time constraints prevent me from integrating AI tools into my lessons.	10 (7.1%)	32 (22.9%)	55 (39.3%)	43 (30.7%)	3.01	Moderate Challenge
7.	Infrastructural deficits in the school impede the use of AI tools.	6 (4.3%)	25 (17.9%)	60 (42.9%)	49 (35.0%)	3.08	High Challenge
8.	Curriculum demands and examination pressure reduce opportunities to use AI tools in STEM lessons.	8 (5.7%)	28 (20.0%)	57 (40.7%)	47 (33.6%)	3.03	High Challenge

Result in table 3 reveals the analysis of challenges faced by STEM teachers in integrating Artificial Intelligence (AI) tools into instruction revealed several significant barriers. Teachers reported that lack of access to computers, reliable internet, and other digital devices posed the greatest challenge (M = 3.26), followed closely by inadequate training on AI tools (M = 3.13), limited technical support in schools (M = 3.15), and insufficient exposure to AI applications

for STEM instruction (M = 3.12). These findings indicate that both infrastructural and professional development limitations are major impediments to effective AI integration. Moderate challenges were identified in areas such as managing large class sizes (M = 2.98) and addressing time constraints in lesson delivery (M = 3.01), suggesting that workload and classroom management issues also affect teachers' capacity to apply AI tools effectively. Systemic factors, including infrastructural deficits (M = 3.08) and curriculum demands coupled with examination pressures (M = 3.03), were also reported as high challenges, highlighting the complex interplay of school-level and policy-level constraints.

Discussion of Findings

The study found that, teachers possessed moderate knowledge of AI, demonstrating awareness of AI concepts and familiarity with AI tools such as simulations, adaptive learning platforms, and intelligent tutoring systems. However, many teachers lacked in-depth understanding of practical applications, including lesson planning, personalized learning, and formative assessment using AI. This finding aligns with global research indicating that, while teachers may be aware of emerging AI technologies, their understanding of pedagogical integration remains limited (Sinatra etal. 2022; Guo, Wang, & Li, 2025). Similarly, studies within Nigeria have highlighted that, teachers often possess general awareness of digital technologies but struggle to apply them meaningfully in classroom settings (Agyekum et al., 2025; Obodo & Ani, 2025). The moderate knowledge observed suggests a need for hands-on training to enhance teachers' practical understanding of AI tools.

Results revealed that, teachers displayed moderate competence, with higher proficiency in planning lessons and selecting appropriate AI tools, but lower skills in troubleshooting technical issues, adapting AI tools to diverse student needs, and providing personalized feedback. These findings are consistent with previous research indicating that awareness does not automatically translate to competence for classroom integration (Bolaji et al., 2025; Guo, Wang, & Li, 2025). The qualitative data confirmed that teachers often plan lessons with AI tools but face difficulties during practical implementation due to lack of confidence or exposure. Enhancing competence requires targeted interventions, including training workshops, mentoring, and continuous hands-on experience, which have been shown to improve teachers' ability to integrate AI into teaching effectively (Baah et al, 2024).

The study identified significant barriers, including inadequate access to computers and the internet, insufficient training, lack of technical support, and limited exposure to AI applications. Other challenges included large class sizes, time constraints, curriculum demands, and infrastructural deficits. These results align with both local and international studies highlighting infrastructural limitations and insufficient professional development as major barriers to technology integration in schools (Agyekum et al., 2025; Obodo & Ani, 2025; Guo, Wang, & Li, 2025). The findings highlight that, without adequate resources, training, and institutional support, teachers are unable to fully harness the potential of AI tools in enhancing student learning outcomes in STEM subjects.

Conclusion

This study examined teachers' knowledge and competence in using AI tools for STEM instruction in public secondary schools in Fagge Education Zone, Kano, Nigeria. Results indicated that, teachers possess a moderate level of knowledge and competence but face challenges in integrating AI effectively due to limited training, inadequate infrastructure, and insufficient technical support. While teachers are familiar with AI tools such as intelligent tutoring systems and adaptive learning platforms, practical application such as lesson planning, personalized feedback, and adaptation for diverse learners remains limited. These findings suggest that enhancing AI-based STEM instruction requires not only teacher knowledge and competence but also systemic support, access to digital resources, and continuous professional development to improve students' engagement and academic performance.

Recommendations

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

1. Government should organize continuous training workshops and seminars to enhance STEM teachers' knowledge and competence in AI tools.
2. Government should equip public secondary schools with adequate computers, reliable internet access, and AI-enabled learning platforms and ensure regular maintenance.
3. Curriculum planners should include AI integration strategies into STEM curriculum guidelines to give teachers structured frameworks for using AI in lessons.

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