ASSESSING SCIENCE TEACHERS' STEM INTEGRATION PRACTICES IN SECONDARY SCHOOL SCIENCE INSTRUCTION: EVIDENCE FROM MINNA EDUCATION ZONE, NIGER STATE.

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Abstract
This study investigated science teachers' Science, Technology, Engineering, and Mathematics (STEM) integration practices in secondary school science instruction in the Minna Education Zone of Niger State, Nigeria. A descriptive survey design was adopted, involving a sample of 291 science teachers selected through multistage sampling from 11 secondary schools across three Local Government Areas. Data were collected using a validated questionnaire titled Instructional Practices of Science Teachers for Promoting STEM Education in the Twenty-First Century, with a reliability coefficient of 0.81. Data analysis was conducted using descriptive statistics such as mean and standard deviation. Findings revealed that the extent of science teachers' implementation of STEM-integrated instructional practices was low (M = 2.10, SD = 0.84), indicating that teachers rarely apply engineering design, open-ended problems, or technology integration in science classrooms. Similarly, instructional strategies that promote STEM learning, such as project-based, inquiry-based, and design-based approaches, were rarely employed (M = 2.24, SD = 0.97), with lecture methods remaining dominant. Moreover, assessment strategies used to evaluate students' learning in integrated STEM education were limited, with teachers relying mainly on traditional methods such as interviews and reflective writing (M = 2.14, SD = 0.88). The study concludes that despite growing emphasis on STEM education, science teachers in the Minna Education Zone have not fully adopted integrative pedagogies and authentic assessments. It recommends continuous professional development programs focusing on STEM integration, provision of adequate instructional resources, to enhance the implementation of effective STEM-based instruction and assessment in secondary schools.

Keywords: *STEM education, instructional practices, instructional strategies, assessment practices, secondary school science teachers*

Introduction
The rapid pace of technological advancement, globalization, and evolving societal needs has made Science, Technology, Engineering, and Mathematics (STEM) education pivotal for preparing students to succeed in the 21st century. STEM integration in instruction enables learners to engage in authentic problem-solving, engineering design, real-world contexts, and technology, thereby fostering critical thinking, creativity, and innovation (Halawa & Hsu, 2024; Crotty, Cox-Petersen, & Lee, 2018). In many countries, including Nigeria, governments, education authorities, and scholars have underscored the importance of STEM to economic development, national competitiveness, and sustainable growth (Aina, 2022; Ukeje & Chiebonam, 2025). However, realising the potential of STEM integration requires not only policy support but also effective teaching practices, appropriate instructional strategies, and valid assessment methods.

In Nigeria, prior studies have pointed out challenges such as inadequate infrastructure, lack of teacher training, insufficient instructional materials, and unclear curriculum guidelines as

impediments to effective STEM instruction (Gimba, Hassan, Yaki, & Chado, 2018; . Despite these recognitions, there is limited empirical data at the local level (for example, in Minna Education Zone, Niger State) on how science teachers implement STEM integration in practice, including the instructional strategies they use, the frequency and fidelity with which they implement them, and how they assess student learning in such settings.

STEM integration involves the deliberate blending of two or more disciplines: Science, Technology, Engineering, and Mathematics to reflect the interconnected nature of real-world challenges, emphasizing inquiry, problem-solving, and design thinking. Effective integration requires teachers to move beyond subject silos to create learning experiences that mirror authentic contexts (Crotty et al., 2018; Fang & Fan, 2022). However, research indicates that many teachers still struggle to establish explicit connections among the STEM domains, often emphasizing science concepts with limited incorporation of technology tools or engineering design processes. This challenge underscores the importance of appropriate instructional and assessment practices that can operationalize STEM integration in classroom settings.

Instructional strategies form the pedagogical bridge that enables meaningful STEM integration. Strategies such as project-based learning, inquiry-based learning, problem-based learning, and engineering design challenges have been shown to enhance learners' engagement, collaboration, and higher-order thinking (Halawa & Hsu, 2024; Mohd Yahya Jusoh *et al.,* 2022). These methods encourage students to apply knowledge across multiple STEM fields, thereby fostering creativity and problem-solving aligned with twenty-first-century learning goals. Yet, in developing contexts such as Nigeria, teachers' adoption of such strategies remains inconsistent, often constrained by inadequate training, limited instructional resources, and heavy workloads (Olabiyi et al., 2021; Gimba *et al.,* 2018). Without robust instructional support, STEM integration efforts risk remaining theoretical rather than practical.

Assessment practices represent the evaluative dimension of STEM integration, ensuring that learning outcomes reflect students' ability to think critically, design solutions, and apply interdisciplinary knowledge. Authentic assessments, such as performance tasks, design rubrics, and formative feedback, are essential for capturing complex learning processes in STEM-based instruction (Halawa & Hsu, 2024). However, studies report that many teachers still rely on traditional tests focusing on content recall, largely due to difficulties in designing valid tools for project-based or integrated learning contexts (Crotty *et al.*, 2018). Consequently, effective STEM education depends on the alignment of integration practices, instructional strategies, and assessment approaches. When these three elements are coherently implemented, they reinforce one another. Integrated curricula promote inquiry-based strategies, which in turn require authentic assessments to measure real-world problem-solving competencies.

This study, therefore, assesses the practices of science teachers in secondary schools in Minna Education Zone with respect to STEM integration, focusing on instructional implementation, strategies, and assessment. Findings are expected to provide evidence for improving teacher preparation, instructional support, and policy implementation in STEM education in Niger State and similar contexts.

Statement of the Problem

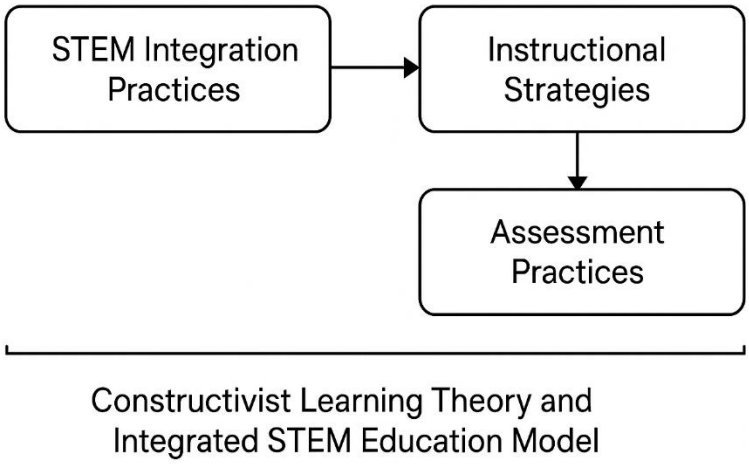
While policy pronouncements and educational reforms in Nigeria emphasise STEM education, there remains a substantial gap between the theoretical expectations of integrated STEM instruction and what actually happens in classrooms. Many science teachers struggle to operationalize STEM instructional practices such as engineering design, open-ended problem solving, real-world contextualization, technology integration, and inquiry questioning. Furthermore, there is scant information about which strategies teachers are using and how they assess STEM-based learning. Without understanding these practices in context, policy efforts and professional development may not adequately address the actual needs, leading to suboptimal student engagement and outcomes. In the Minna Education Zone of Niger State, it is unknown to what extent these instructional and assessment practices are being implemented, what strategies are being employed, and whether these align with 21st century STEM education ideals. This lack of empirical evidence hampers targeted interventions and improvement in science instruction.

Research Questions

1. To what extent do science teachers in secondary schools in Minna Education Zone implement STEM-integrated instructional practices (e.g., engineering design challenges, problem-based learning, technology use, and inquiry questioning)?
2. What instructional strategies do science teachers employ to facilitate integrated STEM learning experiences in secondary science classrooms?
3. What assessment strategies do science teachers use to evaluate students' learning in integrated STEM education?

Conceptual Framework

The conceptual framework illustrates the relationship among the three key constructs of the study: STEM Integration Practices, Instructional Strategies, and Assessment Practices as grounded in the Constructivist Learning Theory and the Integrated STEM Education Model.



In the diagram, STEM Integration Practices form the starting point, representing how teachers combine science, technology, engineering, and mathematics in classroom instruction. These practices directly influence the Instructional Strategies teachers adopt, such as inquiry-based, project-based, and problem-based learning approaches. The effectiveness of these strategies then shapes the Assessment Practices, which evaluate students' ability to apply integrated STEM knowledge through authentic, performance-based tasks.

Research Methodology

This study adopted a descriptive survey design, which enables the researcher to systematically describe a population's characteristics, behaviours, and patterns without manipulating variables. The design was considered appropriate for this investigation because it provides quantitative evidence on teachers' instructional practices for promoting STEM education in the twenty-first century. The population comprised 1,204 science teachers across 160 secondary schools in the Minna Education Zone of Niger State, covering six Local Government Areas—Bosso, Chanchaga, Kagara, Shiroro, Suleja, and Paikoro (Zonal Inspector of Education, Minna, 2021). Using a multistage sampling technique, a total of 291 science teachers were selected from 11 schools in three Local Government Areas (Bosso, Chanchaga, and Suleja). The sample size was determined using the Krejcie and Morgan (1970) table to ensure representativeness while minimizing cost and time.

A structured questionnaire titled *"Instructional Practices of Science Teachers for Promoting Science, Technology, Engineering, and Mathematics Education in the Twenty-First Century"* served as the research instrument. It comprised five sections: (a) demographic information (gender, years of experience, and school location); (b) level of implementation of STEM practices (20 items); (c) instructional strategies used (10 items, rated from Often Used to Never Used); and (d) assessment strategies (12 items). The instrument's face and content validity were established by three experts, one from the School of Environmental Technology, Federal University of Technology, Minna, Niger State, and two from the College of Education, Minna, who evaluated clarity, language, and relevance of items. Reliability was determined using Cronbach's alpha

method on responses from 24 science teachers at Day Secondary School, Minna, yielding a coefficient of 0.81, indicating that the instrument was reliable for data collection.

The researcher visited the selected schools and obtained permission from the school authorities to conduct the study, as well as the informed consent of the respondents. The research instruments were then administered, and the data collected were analyzed using descriptive statistics, including the mean and standard deviation, to address the research questions.

Results

To what extent do science teachers in secondary schools in Minna Education Zone implement STEM-integrated instructional practices? To answer this research question, data were analyzed using mean and standard deviation.

Table 1: Mean and Standard Deviation on the Extent of Science Teachers' Implementation of STEM-Integrated Instructional Practices (N = 291)

S/N	Items	Mean	SD	Decision
1	The learners are always presented with an open-ended problem to guide the lesson.	2.03	0.77	Rarely Implemented
2	Science teaching and learning are linked to a real-world scenario.	2.15	0.92	Rarely Implemented
3	I ensure learning activities in STEM are presented to provide hands-on training to enhance the practical know-how of students.	2.01	0.76	Rarely Implemented
4	Students are asked questions to define the problems to be solved.	1.86	0.78	Rarely Implemented
5	Students are provided with the opportunity to generate ideas to proffer solutions to identified complex problems.	2.03	0.88	Rarely Implemented
6	Students work in small groups to share ideas and communicate with each other.	1.97	0.85	Rarely Implemented
7	Small group discussions and brainstorming are organized for students to work as a team to proffer solutions to identified problems collectively.	2.05	0.76	Rarely Implemented
8	I frequently use the lecture method for science instruction.	3.02	1.0	Often Implemented
9	I include real-life experiences in the teaching of STEM to help in developing critical thinking skills in students.	1.94	0.79	Rarely Implemented
10	I integrate instructional technologies such as mobile learning.	2.2	0.95	Rarely Implemented
11	I engage students in computer-aided instruction to foster meaningful learning of science.	1.83	0.74	Rarely Implemented
—	Average Mean	2.1	0.84	Rarely Implemented

Note. Decision rule: 3.50–4.00 = Always Implemented; 2.50–3.49 = Often Implemented; 1.50–2.49 = Rarely Implemented; 1.00–1.49 = Never Implemented.

The results presented in Table 1 show that the overall mean score for science teachers' implementation of STEM-integrated instructional practices was 2.10 (SD = 0.84), corresponding

to the decision level of Rarely Implemented. This indicates that, on average, science teachers in the Minna Education Zone infrequently adopt STEM-integrated instructional approaches in their classrooms.

A closer inspection of the items reveals that practices such as presenting open-ended problems (M = 2.03, SD = 0.77), linking science instruction to real-world scenarios (M = 2.15, SD = 0.92), organizing small group discussions (M = 2.05, SD = 0.76), and integrating instructional technologies (M = 2.20, SD = 0.95) were all rarely implemented. Only the use of the lecture method (M = 3.02, SD = 1.00) was reported as often implemented, indicating a continued reliance on conventional teaching methods rather than inquiry-based or technology-enhanced approaches. These findings suggest a low level of STEM integration in science classrooms across the Minna Education Zone, possibly due to inadequate professional development, limited instructional resources, or insufficient exposure to integrated STEM pedagogy.

What instructional strategies do science teachers employ to facilitate integrated STEM learning experiences in secondary science classrooms? To address this research question, data were analyzed using mean and standard deviation.

Table 2: Mean and Standard Deviation on Instructional Strategies Used by Science Teachers (N = 291)

S/N	Instructional Strategies	Mean	SD	Decision
1	Design-based Learning	2.23	0.94	Rarely Used
2	Project-based	2.36	0.82	Rarely Used
3	Flipped Classroom	2.07	0.84	Rarely Used
4	Problem-Based Learning	2.35	1.11	Rarely Used
5	Peer Instruction	2.29	0.91	Rarely Used
6	Lecture	3.28	0.91	Used
7	Computer-Based Instruction	2.23	1.0	Rarely Used
8	Think-Pair-Share	2.22	0.98	Rarely Used
9	Drill & Practice	2.18	1.07	Rarely Used
10	Class or Small-Group Discussion	2.11	0.84	Rarely Used
11	Experiments	2.06	0.91	Rarely Used
12	Inquiry-Based	1.76	0.82	Rarely Used
—	Average Mean	2.24	0.97	Rarely Used

Note. Decision key: 1.00–1.49 = Not Used; 1.50–2.49 = Rarely Used; 2.50–3.49 = Used; 3.50–4.00 = Often Used.

The results in Table 2 indicate that the overall mean score for instructional strategies employed by science teachers to promote integrated STEM learning was 2.24 (SD = 0.97), which falls within the range of *Rarely Used.*

This finding suggests that science teachers in secondary schools within the Minna Education Zone infrequently employ instructional strategies that promote integrated STEM learning experiences. Item-by-item analysis shows that strategies such as design-based learning (M = 2.23, SD = 0.94), project-based learning (M = 2.36, SD = 0.82), problem-based learning (M = 2.35, SD = 1.11),

inquiry-based learning (M = 1.76, SD = 0.82), and computer-based instruction (M = 2.23, SD = 1.00) were all rarely used by teachers. The only strategy that appeared to be used was the lecture method (M = 3.28, SD = 0.91), indicating that most teachers still rely heavily on teacher-centered, traditional instructional methods. This pattern highlights limited adoption of innovative, student-centered pedagogies that are essential for effective STEM integration.

What assessment strategies do science teachers use to evaluate students' learning in integrated STEM education? Mean and Standard Deviation were used to answer research question three, as shown in Table 3

Table 3: Mean and Standard Deviation on instructional assessment used by science teachers (N=291)

S/N	Instructional Assessment	Mean	Std.	Decision
1	Interviews	2.54	0.97	Used
2	Reflective Writing	2.50	0.84	Used
3	Projects	2.41	0.96	Rarely Used
4	Quizzes and Polls	2.26	0.85	Rarely Used
5	Diagnostic assessment	2.24	1.00	Rarely Used
6	Experiments Report	2.17	1.01	Rarely Used
7	Peer Review Exercises	2.07	0.82	Rarely Used
8	Essay-Type Questions	2.04	0.83	Rarely Used
9	Self-Assessments	2.03	0.94	Rarely Used
10	Group presentations	1.97	0.76	Rarely Used
11	Performance and formative assessment	1.93	0.86	Rarely Used
12	Assignments	1.53	0.73	Rarely Used
	Average Mean	**2.14**	**0.88**	**Rarely Used**

Decision key: Not Used = 1.0 – 1.49, Rarely Used = 1.5 - 2.49, Used = 2.5 – 3.49 and Often Used = 3.5 – 4.0

The results in Table 3 reveal that the overall mean score was 2.14 (SD = 0.88), indicating that assessment strategies for integrated STEM learning were *rarely used* by science teachers in the Minna Education Zone. This finding suggests that teachers rely more on traditional assessment methods rather than authentic or performance-based assessments that align with STEM integration principles.

Item-wise analysis shows that only interviews (M = 2.54, SD = 0.97) and reflective writing (M = 2.50, SD = 0.84) were rated as *used*, while other strategies such as projects (M = 2.41, SD = 0.96), experiments report (M = 2.17, SD = 1.01), peer review exercises (M = 2.07, SD = 0.82), and group presentations (M = 1.97, SD = 0.76) were *rarely used*. The lowest mean scores were recorded for assignments (M = 1.53, SD = 0.73) and performance/formative assessments (M = 1.93, SD = 0.86), indicating limited use of authentic assessment methods. Overall, these results reflect the predominance of teacher-centred evaluation methods and highlight a need for capacity building in effective STEM-aligned assessment practices.

Discussion of Findings

Overall, the results revealed that science teachers rarely implement integrated STEM instructional practices, seldom use innovative instructional strategies, and depend largely on traditional assessment methods. These outcomes reflect a persistent gap between policy intentions and classroom realities in STEM education within the region. STEM-Integrated Instructional Practices The results from Research Question One indicated that STEM-integrated instructional practices such as inquiry questioning, engineering design, and problem-based learning are rarely implemented by science teachers. The overall mean score of 2.10 (SD = 0.84) shows that teachers infrequently engage students in activities that promote critical thinking, collaboration, or hands-on problem solving. Only the lecture method was often used, indicating a strong reliance on conventional, teacher-centered pedagogy. This finding agrees with earlier studies Gimba et al., (2018) that reported similar patterns across Nigerian schools. From the theoretical perspective, these findings are consistent with Constructivist Learning Theory, which posits that learners construct knowledge actively through authentic experiences. The limited adoption of hands-on, inquiry-based activities suggests that many teachers still operate within a transmission-based instructional paradigm, rather than a constructivist, learner-centred model, thereby hindering students' opportunities for experiential learning and knowledge application.

Results from Research Question Two revealed that most teachers rarely use student-centred instructional strategies such as project-based, inquiry-based, and design-based learning, with an overall mean of 2.24 (SD = 0.97). The lecture method was again the most frequently used strategy (M = 3.28, SD = 0.91). This finding aligns with those of Crotty, Cox-Petersen, and Lee (2018) and Mohd Yahya Jusoh et al. (2022), who observed that while STEM education emphasizes active participation, collaboration, and problem-solving, teachers often default to lecture-oriented instruction due to limited training and time constraints.

For Research Question Three, the results showed that assessment strategies aligned with STEM pedagogy were rarely used, with an overall mean of 2.14 (SD = 0.88). Most teachers relied on interviews and reflective writing, while more authentic assessment forms such as performance tasks, peer review, and project evaluations were seldom applied. These findings mirror those of Halawa and Hsu (2024), who emphasized that STEM assessment should evaluate students' capacity for design thinking, collaboration, and innovation rather than rote recall. The prevalent use of traditional tests indicates a disconnection between learning objectives and evaluation approaches, thereby limiting students' ability to demonstrate authentic STEM competencies.

Conclusion

This study concludes that science teachers in secondary schools in the Minna Education Zone exhibit a generally low level of STEM integration in their instructional, strategic, and assessment practices. The findings revealed that while teachers recognize the relevance of STEM, they often revert to conventional lecture-based teaching, rarely incorporating hands-on, inquiry-based, or technology-driven learning experiences.

Recommendations

1. The Ministry of Education and school administrators should organize continuous professional development workshops focused on STEM-integrated pedagogy, emphasizing inquiry-based and project-based approaches.

2. Pre-service and in-service teacher education programs should include practical modules on STEM integration, emphasizing the use of instructional technologies and design thinking.
3. Schools should provide adequate facilities and resources—such as laboratories, ICT tools, and instructional materials—to support hands-on STEM activities.
4. Assessment systems should be restructured to incorporate authentic performance-based evaluation aligned with STEM learning outcomes.

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