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Teachers' Implementation of Integrated Science, Technology, Engineering and Mathematics (STEM) Education in Nigeria: Roles of Gender, Qualification and Teaching Experience

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ABSTRACT Some nations have already subscribed to STEM education and have continued to champion its progress, however, others seem to be lagging far behind in STEM education. This study, therefore, investigated the teaching of integrated STEM Education in Nigeria. Guided by four research questions and three hypotheses, the study employed a descriptive research approach. A sample of 207 STEM teachers drawn using proportionate and simple random sampling techniques participated in the study. A structured questionnaire developed by the researchers was used for data collection. The reliability index of the instrument, as obtained using Cronbach's alpha, was 0.84. Descriptive and inferential statistics were used for data analysis. The findings revealed a low level of the implementation of Integrated STEM Education (ISTEME). Additionally, teacher qualification significantly influenced teachers' implementation of ISTEME. However, both gender and teaching experience had no significant influence on the teaching of ISTEME. It is concluded that STEM education in Nigeria still operates at low level and teachers' qualification has a significant role on its implementation. In light of the findings, recommendations were proffered.

INTRODUCTION

The growing need for advancement in science and technology in society has continued to reshape educational policies and programs to align with societal aspirations. Essentially, most of these recent policies and programs are designed to prepare students to contribute to solving contemporary problems using 21st century skills. One of the recent programs that nurtures students to become problem solvers is "STEM or Science, Technology, Engineering and Mathematics". Interestingly, some developed nations, such as the USA, England and Japan, have recognised the importance of STEM education and have equally developed a framework for its implementation (Tunc and Bagceci 2021). However, while most developed nations have subscribed to STEM education, most developing nations, especially in Africa, seem to be lagging far behind in STEM education.

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Emerging studies on STEM education have reported the positive impact of Integrated STEM Education (ISTEME) on students' learning outcomes as compared to traditional teaching practices (Kurt 2025; Portillo-Blanco et al. 2025), suggesting that teachers should adopt a more innovative approach, such as ISTEME, rather than relying on traditional instructional methods. While studies have reported the level of teaching of STEM education in countries such as Malaysia (Razal et al. 2022), the USA (Shernoff et al. 2017), South Africa (Mafugu et al. 2024), and Canada (Tunc and Bagceci 2021), the instructional approaches involved in STEM education in Nigeria has remained unexplored. In addition, previous studies have identified several factors that affect the teaching of STEM education. However, there is a scarcity of research on the impact of teachers' demographic factors (such as gender, teaching experience and location) on their implementation of STEM. Hence, there is a need for the present study on teachers' teaching of STEM education in Nigeria.

STEM is the acronym for "Science, Technology, Engineering and Mathematics", which denotes the practice of learning science and mathematics by relating them to technology and engineering applications. Historically, STEM originated in the United States of America and was first used in the early 1900s (Blackley and Howell 2015).

Since the introduction of STEM, various conceptualisations and definitions of STEM and STEM education have emerged (Jamil et al. 2023). For instance, STEM education is defined as the teaching and learning of at least two STEM disciplines within a single subject (Li et al. 2024; Rillero et al. 2025). It is a flexible educational approach that applies to all levels of education, involving the integration of STEM disciplines (Tunc and Bagceci 2021). Integrated STEM, according to the National Research Council (NRC 2014), is a planned system of building relationships between and within STEM disciplines. ISTEME requires teachers to participate in engineering with the intention to apply mathematics and science in the development of technology by building links with them (Jones et al. 2024; Sari and Akman 2024).

Despite the various definitions of ISTEME, it can be inferred from these definitions that ISTEME is activity-based and embedded in constructivist theory. Student-centred education is a pedagogical approach that fosters the development of problem-solving and 21st century skills in students (Stohlmann et al. 2012). Several studies have reported the positive impact of STEM-based education on students' learning outcomes (Razal et al. 2022), including the development of 21st century skills, knowledge, and competencies (Tunc and Bagceci 2021). STEM education enhances students' interest in STEM and, at the same time, deepens students' knowledge and understanding of engineering design and the interconnectedness with science and mathematics (Mustafa et al. 2016).

While all four disciplines in STEM are of paramount importance, Mathematics seems to stand out owing to its fundamental and linking roles in connecting science, engineering, and technology. Mathematics is described as an indispensable subject needed for scientific and technological advancement (Ogbu 2025a; Ogbu and Emeji 2023). Hence, nations that wish to achieve technological advancement are often encouraged to prioritise learning mathematics (Emeji et al. 2021). Mathematical knowledge can be applied not only to solving mathematical problems for examination purposes, but also to solving real-life problems that span various disciplines (Ogbu 2025b). Given the position of mathematics in STEM learning, mathematics teachers, especially in developing nations, are expected to demonstrate adequate skills in implementing STEM-based learning so as to harness the full potential of STEM education.

Several nations seem to have understood the potential of STEM education for both individual and national development. Of course, STEM education is designed to enable nations to empower students who will solve pressing individual and national real-world problems (Razal et al. 2022). Consequently, developed countries such as the USA, England and Japan have since recognised the importance of STEM education and have implemented several programs aimed at facilitating it (Tunc and Bagceci 2021). The usefulness of STEM education has been reported by several researchers, implying that its importance cannot be overstated. For instance, STEM-based robotic tasks facilitate critical thinking, teamwork, effective communication, and efficient data analysis (Tunc and Bagceci 2021). STEM education enables individuals to acquire the skills needed for employment (Reynante et al. 2020). From the foregoing, individuals who want to remain relevant in contemporary society are expected to acquire a STEM education.

Despite the relevance of STEM education, a plethora of challenges face its implementation. These challenges include an unclear or inconsistent approach for the teaching of integrated STEM (Roehrig et al. 2021), as well as a significant lack of instructional materials, infrastructure, and specialised curriculum resources (Odesomi 2023; UNESCO 2024), limited pedagogical knowledge in STEM disciplines (Razal et al. 2022), and insufficient professional development on how to implement STEM (Boz 2023). Other challenges facing the effective teaching of integrated STEM include a lack of a unified framework and practical guidelines on how to implement STEM education (Dare et al. 2018). While these factors have been identified, there is a scarcity of studies that have examined the impact of teachers' demographic characteristics, such as their gender, qualifications, and teaching experience, on their implementation of ISTEME, especially in developing countries.

Studies on STEM Education

STEM education is the teaching and learning of STEM in a holistic approach. Over the last two decades, numerous studies have been conducted in the field of STEM education. Razal et al. (2022), for instance, investigated the level to which Design and Technology teachers in the East Coast of Malaysia implement ISTEME. The authors reported that Design and Technology teachers did not implement ISTEME mainly because integrated STEM was not part of their teaching practices.

Similarly, Tunc and Bagceci (2021) explored the perceptions of Mathematics, Science, and Information and Communication Technology teachers at Gaziantep Province on the implementation of the STEM approach in their schools. It was observed that while the teachers viewed STEM as having a positive impact on learning outcomes, they were reluctant to implement STEM education. In South Africa, perceptions of ISTEME are influenced by a lack of knowledge about ISTEME (Mafugu et al. 2024).

A meta-analysis of STEM education in Indonesia shows that teachers have a diverse view on the implementation of STEM, which includes anchoring STEM learning in "the integration of STEM disciplines, student engagement, the use of context and content, and students' involvement and activity in the learning process" (Nugraha et al. 2023:21). A study on teachers' experience in implementing STEM education found that most teachers struggled to implement ISTEME (Dare et al. 2018). Moreover, K-12 teachers in the East Coast of the USA, although showing interest in STEM education, lacked confidence in their ability to implement it (Shernoff et al. 2017).

From the foregoing, studies have explored the methods and level of STEM education implementation in several countries, involving teachers ranging from elementary to high school in areas such as Mathematics, Science, Technology and Engineering. However, most of these studies were conducted outside Nigeria, implying that there are few or no studies that have examined the level of ISTEME implementation in Nigeria. Therefore, understanding the status of ISTEME implementation in Nigeria and roles of gender and qualification becomes not only instructive but also timely.

Teachers' Demographic Factors and STEM Education

Effective implementation of ISTEME demands that every barrier be identified and squarely addressed. Although most studies appear to focus on other factors, a few have examined teacher-related factors (Ibrahim 2025). For instance, Talib et al. (2024) explored factors that drive teachers' readiness to implement STEM education and identified factors such as limited professional development, high pedagogical knowledge, and innovative technology usage as influential. It was also observed that teachers' professional development has a significant influence on their self-efficacy in implementing STEM (Kelley et al. 2020).

A positive linear relationship was found between teachers' level of education and teachers' self-efficacy in ISTEME (Mai et al. 2023). School location also significantly contributes to teachers' awareness and confidence in the teaching of integrated STEM, favouring urban school teachers (Mai et al. 2023). Unfortunately, most of the few studies that examined teacher factors related to STEM education seem to focus mainly on teachers' professional development (Talib et al. 2024; Kelley et al. 2020), while fewer considered factors such as school location and teachers' self-efficacy (Mai et al. 2023). In the Nigerian context, studies on the roles of teacher variables such as gender, qualification, and years of teaching in teachers' teaching of STEM education are lacking. Given that teachers' gender, qualification, and teaching experience impact mathematics teachers' mastery of curriculum content (Ogbu and Anyaegbu 2018), gaining insight into the roles of these factors in the teaching of STEM education could help facilitate interventions necessary for effective STEM education in Nigeria.

Impact of Gender on STEM Education

Gender is a term that society often uses to describe differences in the social roles of men and women. It extends beyond sex which refers to the biological differences between men and women. According to Durrani and Kataeva (2025), gender is "a relational category constructed through dominant discourses." Several studies have examined the role of gender in education. In recent times, the gender gap in academic achievement is becoming negligible. However, women have continued to be underrepresented in STEM-related professions and programs (Idrizi et al. 2023).

In online courses, male STEM students slightly outperformed their female counterparts (Idrizi et al. 2023). Teachers' gender is one of the sources of gender bias in recommending STEM-based careers to students (Andersen 2021). An examination of high school students' interest in STEM revealed that male students demonstrated higher interest in most of the dimensions of interest as compared to female students. However, a significant influence of gender on students' basic knowledge of STEM was in favour of the female students (Tekin and San 2023). Gender disparity in STEM education is caused by culture, the adopted educational system, and the teachers who teach STEM (Alghneimin et al. 2024), as well as STEM-related qualifications acquired by the teachers.

Impact of Teachers' Qualification on STEM Education

Teachers are not only expected to be knowledgeable in their area of specialisation but also to be versatile in sciences to facilitate transfer of learning among students. The quality of teachers is fundamentally measured by the certificates that enable them to practice. In Nigeria's educational system, secondary school teachers are expected to possess a minimum of NCE (National Certificate in Education). Ideally, those who have NCE certificates are expected to teach in junior secondary school, whereas those with a minimum of a Bachelor's Degree are required to teach at the senior level.

Qualified teachers are vital for the effective teaching of STEM education. Teachers' quality can be enhanced through professional development, adequate funding of education, and the strengthening of teachers' training programs. Similarly, an effective curriculum, increased motivation, and teachers' assistance in implementing STEM education are fundamental in improving teachers' quality in STEM education (Syafril et al. 2021). Teacher qualification significantly influences teacher basic knowledge in STEM (Tekin and San 2023). Based on existing literature, studies on the role of teachers' academic qualifications in their teaching of STEM education are scarce, despite the substantial literature on gender-based studies in education globally. This study aims to bridge this gap by exploring not only the status of STEM education teaching in Nigeria but also the impact of teachers' qualifications and years of teaching experience on the implementation of STEM activities.

Impact of Teaching Experience on STEM Education

Years of teaching experience measure how long a teacher has been in their teaching profession. Although there is no universally accepted standard for classifying teachers by experience level, it is often assumed that a higher number of years implies greater teaching experience, while a lower number of years indicates less experience. In this study, years of teaching experience is categorised into three, as 1-5 years, 6-10 years, and above 10 years.

With respect to STEM, teachers with a minimum of five years of teaching experience are reported to still encounter significant difficulties in implementing STEM education (Thang 2021). Years of teaching experience significantly influence teachers' basic knowledge of STEM education (Tekin and San 2023). It is worth mentioning that having subject matter knowledge does not automatically translate to pedagogical knowledge, implying that a study examining the impact of teaching experience on teachers' teaching of STEM education, rather than just basic knowledge of STEM, is worthwhile.

Study's Framework

This study employs the Framework for ISTE-ME developed by Kelly and Knowles (2016). This framework posits that effective real-life problem-solving skills can be easily developed in students by using an integrated approach, where relevant experiences are linked to STEM disciplines, rather than merely teaching content and skills to students. This framework, unlike others, is specifically designed for teaching STEM education at the secondary school level (Kelly and Knowles 2016), unlike other STEM frameworks that are not suitable for this level of education. This framework was considered appropriate for this study, as it clearly shows the relationship among the variables examined in the study. The three selected teachers' demographic factors are their gender, academic qualifications, and years of teaching experience. The schema indicates that these demographic factors may impact teachers' teaching of STEM education, which in turn could lead to improvements in learning outcomes in STEM. These improvements could lead to an increase in students' level of engagement, interest, academic achievement, and problem-solving skills in STEM. The framework is related to this study being that it explains how STEM education should be implemented where teaching STEM teaching should link content to real life events. Hence, there is a need for a proper understanding of the status of Science and Mathematics teachers' implementation of ISTEME at the secondary school level in Nigeria. More importantly, the complex nature of ISTEME requires that teachers, regardless of their gender, have the necessary qualifications and be versatile in STEM disciplines in order to effectively implement STEM education.

Objectives of the Study

The main objective of this study was to assess science and mathematics teachers' implementation of ISTEME Nsukka Education Zone, Enugu State Nigeria and the roles of teachers' gender, qualification, and teaching experience in the implementation of the ISTEME.

Research Questions and Hypotheses

In order to achieve these aforementioned objective, the following research questions and hypotheses were answered and tested in this study:

1. What is the level of the implementation of ISTEME in this area?
2. What is the impact of teachers' gender on the implementation of ISTEME?

Hypothesis 1: Teachers' gender has no significant impact on teachers' implementation of ISTEME.

3. What is the impact of teachers' qualification on the implementation of ISTEME?

Hypothesis 2: Teachers' qualification has no significant impact on teachers' implementation of ISTEME.

4. What is the impact of teachers' years of teaching experience on the implementation of ISTEME?

Hypothesis 3: Teachers' years of teaching has no significant impact on teachers' implementation of ISTEME.

METHODOLOGY

Design and Area of the Study

A descriptive survey design was adopted for this study. A descriptive survey uses data collected from a representative sample of a population to describe the attributes of that population. A descriptive survey research approach was deemed appropriate for this study because a sample of science and mathematics teachers was used to gather data that enabled the researchers to describe the teachers' attributes (the implementation of ISTEME).

This research was carried out within the Nsukka Education Zone, situated in the northern part of Enugu State, Nigeria. Enugu, known as the "Coal City" due to its significant coal deposits, is one of the five states comprising South-Eastern Nigeria. Beyond universities, the area features numerous secondary schools, including both single-sex and mixed institutions, all of which offer a diverse range of subjects such as Mathematics, Physics, Chemistry, and Biology.

The diverse population in this area includes traders, farmers, civil and public servants, artisans, and students. The predominant occupations are trading, farming, and civil service, with key agricultural products being yam, cassava, maize, and various vegetables. While the majority of residents are of Igbo nationality, a smaller number of non-Igbo individuals also reside here. Christianity is the primary religion, though there has been a noticeable increase in traditional worshippers over the past decade (Ogbu 2025a).

Participants

The study population consisted of 429 science and mathematics teachers, comprising 101 Biology teachers, 98 Chemistry teachers, 143 Mathematics teachers, and 87 Physics teachers, distributed across 60 public secondary schools in the zone. The study sample consisted of 207 teachers. This size was determined using the Taro Yamane Formula (Yamane 1967). The sample was drawn using a two-stage sampling procedure. Stage one comprising proportionate random sampling was initially employed to ensure that the size of the sub-populations was accurately represented in the sample. This procedure resulted in the inclusion of 49 Biology, 47 Chemistry, 69 Mathematics, and 42 Physics teachers in the sample. Stage two determined the proportion of teachers needed from each group, the second stage involved using simple random sampling without replacement to draw the required number of subsamples from the subpopulation. This was accomplished by numbering the sample frame and applying simple random sampling through a ballot.

Data Collection Tools

A questionnaire titled "Teachers' Implementation of ISTEME Scale (TIISTEMES)," a structured questionnaire developed by the researchers, was used for data collection in this study. The TIISTEMES has two sections, A and B. Section A contains instructions that guide the completion of the questionnaire and demographic information for the teachers, including their gender, academic qualifications, and years of teaching experience. Part of the instruction assures the teachers of their confidentiality and solicits their honesty in responding to the questions. Section B contains 15 items that measure teachers' implementation of ISTEME. The TIISTEMES contains questions such as "I make my students see the connections between STEM disciplines when delivering instruction", "I employ technological resources to deliver STEM-based instruction", "I integrate engineering designs in delivering instruction in my subject", and so on. The indicators of TIISTEMES are presented in Table 2. The TIISTEMES was developed after an extensive literature review. The scale was rated on a 4-point scale with Not At All (NAA = 1 point), Sometimes (S = 2 points), Often (O = 3 points), and Very Often (VO = 4 points). Higher scores on the TIISTEMES indicate high implementation of ISTEME, whereas low scores indicate low implementation. The minimum and maximum obtainable summated scores on the TIISTEMES are 15 and 60, respectively.

The TIISTEMES was validated by three lecturers, that is, one in Mathematics Education, one in Chemistry Education, and one in Physics Education from a federal university in Nigeria. The lecturers were asked to vet the items in terms of clarity and appropriateness for secondary school Mathematics and Science teachers. The experts made several suggestions, including reducing the length of questions to improve clarity and incorporating items that measure both integrated STEM and non-integrated STEM. In light of the experts' suggestions, overly long items were revisited, and items 6 and 9 were added to the final draft of the TIISTEMES.

The TIISTEMES was pilot tested on 30 Science and Mathematics teachers outside the study area. The teachers used in the pilot study have similar characteristics to those in this study, as they both teach students using the same curriculum, are supervised by the same state government, and follow the same academic calendar. The responses obtained from the teachers were submitted to Cronbach's alpha analysis using the Statistical Package for the Social Sciences (SPSS) version 25. A reliability index of 0.84 was obtained, suggesting that the TIISTEMES demonstrated good reliability.

Method of Data Collection and Analysis

The researchers first obtained ethical clearance from the University Research Ethics Committee. To ensure confidentiality, the respondents were not allowed to indicate their names or the names of their school. Moreover, they were informed that the data would be used only for research purposes. The principals of the sampled schools were visited and informed about the purpose of the study. Through the principals the Mathematics and Science teachers were contacted, and their consent was obtained. Because the TIISTEMES contains few questions, the teachers were allowed to respond to the instrument and return it to the researchers. This was done to ensure a high return rate. The collected data were analysed using SPSS version 25. The data were first screened for missing values, and none were found. The summated scores were further screened for outliers using the Pearson skewness and kurtosis coefficients. There were no strong outliers, as both the skewness and kurtosis values fell within the acceptable ranges, as shown in Table 1.

The summated scores were also evaluated for the key t-test and Analysis of Variance (ANOVA) assumptions. Specifically, normality assumptions were checked using the Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) tests. The data did not violate the assumption of normality. Similarly, the homogeneity of variance assumption was tested using Levene's test, and the data did not significantly violate this assumption regarding the levels of the independent variables in this study. Therefore, the research questions were answered using the mean and standard deviation. Specifically, research question 1 was answered with mean ratings below 2.50 indicated Low Implementation (LI), whereas mean ratings of 2.50 and above implied High Implementation (HI). Null Hypothesis 1 was

Table 1: Tests of normality assumption

	Kolmogorov-Smirnov[a]			*Shapiro-Wilk*			*Skewness*		*Kurtosis*	
	Stat.	*df*	*Sig.*	*Stat.*	*Df*	*Sig.*	*Stat.*	*Std. error*	*Stat.*	*Std. error*
Score	0.06	207	0.20	0.99	207	0.05	0.11	0.17	-0.34	0.34

Source: Authors, July 2025

tested using a t-test, while Null Hypotheses 2 and 3 were tested using ANOVA at the 0.05 level of significance.

RESULTS

Tests of Normality Assumption

Table 1 shows the result obtained to evaluate the normality assumption of the scores obtained on teachers' implementation of ISTEME. The result shows that there was no serious violation of normality *(K-S=0.06, P=0.2)* and *(S-W=0.99, P=0.05*). This is further supported by the Pearson skewness and kurtosis values of 0.11 and -0.34 that were within the acceptable ranges of -0.20 to +0.20 and -1.96 to +1.96, respectively.

Research Question 1

What is the level of science and mathematics teachers' implementation of ISTEME in Nsukka Education Zone?

Mean and Standard Deviation Ratings of Teachers on Implementation of ISTEME

Table 2 shows the result of the descriptive statistics conducted to determine the level of the implementation of ISTEME at the Education Zone,

Table 2: Mean and standard deviation ratings of teachers on implementation of ISTEME

S. No.	*Indicators*	*Mean*	*SD*	*Remarks*
1	I make my students see the connections between STEM disciplines when delivering instruction.	1.69	0.88	LI
2	I employ technological resources to deliver STEM-based instruction.	2.21	0.86	LI
3	I integrate engineering designs into my instruction in my subject.	2.02	0.95	LI
4	I give my students project work that challenges them to combine two or more STEM disciplines in performing.	1.85	1.07	LI
5	I give my students the opportunity to come up with tasks requiring a combination of STEM disciplines to solve.	1.96	0.95	LI
6	I focus on delivering instruction solely on my subject area and not in STEM education.	2.07	0.91	LI
7	I deliver my lessons in such a way that my students appreciate the fundamental role of mathematics in sciences.	1.81	1.02	LI
8	I deliver instruction in such a way that my students can easily see the Importance of science and mathematics in decision making.	2.00	0.93	LI
9	I focus only on the curriculum content of the subject I teach and pay little attention to integrated STEM education	1.93	0.95	LI
10	I teach my students how to solve problems using different approaches.	1.99	0.94	LI
11	I lead my students to carry out an investigation, design experiments, analyse data and draw conclusions using integrated STEM context.	1.72	0.91	LI
12	I implement problem-based learning using various STEM concepts to solve real world problems.	1.73	0.98	LI
13	I make students learning of STEM concepts interesting by facilitating collaboration among the students.	2.33	0.86	LI
14	I assess my students not only in my subject area but in relation to their learning of STEM education.	1.74	0.93	LI
15	I collaborate with my colleagues to design STEM-based instructions.	2.01	0.96	LI
	Grand Mean	1.94	0.94	LI

Key: SD=Standard Deviation, LI= Low Implemented

Enugu State, Nigeria. The teachers' mean rating scores on implementation of ISTEME ranged from 1.69 to 2.33, which were well below the 2.50 benchmark, indicating low implementation of ISTEME. The standard deviation ratings ranged from 0.86 to 1.07, implying that the teachers had similar response patterns. The grand mean value of 1.94 further showed that the overall implementation of ISTEME at the Education Zone, Enugu State Nigeria is low.

Research Question 2 and Hypothesis 2

What is the influence of gender on Mathematics teachers' implementation of ISTEME?

Hypothesis: There is no statistically significant influence of gender on the implementation of ISTEME by mathematics teachers.

Mean, Standard Deviation and Independent t-test Show No Significant Influence of Gender on Teachers' Implementation of ISTEME

Table 3 shows the mean, standard deviation, and the result of an independent t-test conducted to determine the influence of gender on teachers' implementation of ISTEME. The following assumptions of the independent t-test for normality and homogeneity of variance were first checked and met. The males had a mean rating score (M=28.88, SD=7.30) slightly below that of the female teachers, who had a mean rating score *(M=29.18, SD=6.71)*. The standard deviation values of 7.30 and 6.71 for the male and female groups indicated that the ratings of the male group spread more from the mean as compared to the female group. The independent t-test further indicated that the mean ratings of the female *(M=29.18, SD=6.71)* was not significantly higher ($t = -0.31, df = 205, p = 0.76$) than male teachers *(M=28.88, SD=7.30)*. The null hypothesis was therefore upheld, implying that gender was not a factor that impacts teachers' implementation of ISTEME in Nigeria.

Research Question 3 and Hypothesis 3:

What is the influence of teacher qualification on Mathematics teachers' teaching of STEM education in Nsukka Education Zone, Enugu State, Nigeria?

Hypothesis: There is no significant influence of teacher qualification on mathematics teachers' teaching of STEM education.

Mean, Standard Deviation, ANOVA Showing a Significant Influence of Qualification on the Implementation of ISTEME

Table 4 shows the result of the descriptive statistics (mean and standard deviation) and inferential statistics (analysis of variance) conducted to determine the impact of teachers' qualification (NCE, Bachelor's Degree, and Masters/Ph.D) on teachers' implementation of ISTEME in Nsukka Education Zone, Enugu State, Nigeria. To check whether qualification has significant influence on Science and Mathematics teachers' implementation of ISTEME, the following major assumptions of ANOVA for normality and homogeneity of variance were first checked and met. Teachers' with NCE had the least mean rating *(M=26.01, SD=6.69)* followed by teachers with Bachelor's Degree *(M=29.51, SD=6.98)* while teachers' with Masters/Ph.D. recorded the highest mean ratings *(M=30.68, SD=6.40)*. The standard deviation values of 6.69, 6.98, and 6.40 for NCE, Bachelor's Degree, and Masters/Ph.D. indicated that the scores for the teachers with Bachelor's Degree varied most from the mean, followed by NCE and then Masters/Ph.D. The analysis further indicated that qualification had a significant impact on teachers' implementation of ISTEME *(F(2, 204)= 6.48, P=0.00<0.05)*. Since the obtained P-value of 0.00 was less than the stated 0.05 level of significance, the null hypothesis was therefore rejected, implying that qualification was a significant factor in teachers' implementation of ISTEME.

Table 3: Mean, standard deviation and independent t-test showing no significant influence of gender on teachers' implementation of ISTEME

Gender	*N*	*Mean*	*SD*	*T*	*Df*	*P-value*	*Decision*
Male		80	28.88	7.30	-0.31	205	0.76
Not significant							
Female	127	29.18	6.71				

Source: Authors, July 2025

Table 4: Mean, standard deviation, ANOVA showing a significant influence of qualification on the implementation of ISTEME

Qualification	*N*	*Mean*	*SD*			
NCE	47	26.01	6.69			
Bachelor's Degree	101	29.51	6.98			
Masters/Ph.D	69	30.68	6.40			
ANOVA	*Sum of squares*	*df*	*Mean square*	*F*	*P-value*	*Decision*
Between groups	590.40	2	295.20	6.48	0.00	Significant
Within groups	9299.79	204	45.59			
Total	9890.18	206				

Source: Authors, July 2025

Research Question 4 and Hypothesis 4

What is the influence of teaching experience on Mathematics teachers' teaching of STEM education in Nsukka Local Government Area?

Hypothesis: There is no significant influence of teaching experience on mathematics teachers' teaching of STEM education.

Mean, Standard Deviation, ANOVA Showing no Significant Influence of Teaching Experience on the Implementation of ISTEME

Table 5 data shows the mean, standard deviation, and ANAOVA conducted to ascertain the impact of years of teaching experience on teachers' implementation of ISTEME in Nsukka Education Zone, Enugu State, Nigeria. Normality and homogeneity of variance were first evaluated and met. Teachers who have 1-5 years of teaching experience had the highest mean rating (M=29.32, SD=7.43), followed by teachers with over 10 years of teaching experience (M=29.06, SD=6.79), while teachers with 6-10 years of teaching experience recorded the lowest mean ratings *(M=28.95, SD=6.79)*. The standard deviation values of 7.43, 6.79, and 6.93 for teachers' with 1-5, 6-10, and more than 10 years teaching experience indicated that the scores for the teachers with 1-5 years teaching experience varied most from the mean, followed by teachers with over 10 years teaching experience, and teachers' with 5-10 years teaching experience. The result further indicated that teachers' years of teaching experience had no significant influence on their implementation of ISTEME (F(2, 204)=0.04, P=0.97 *> 0.05)*. Since the obtained P-value of 0.97 was greater than the stated 0.05 level of significance, the null hypothesis was therefore not rejected, implying that teachers' years of teaching experience had no significant influence on teachers' implementation of ISTEME.

Table 5: Mean, standard deviation, ANOVA showing no significant influence of teaching experience on the implementation of ISTEME

Teaching experience	*N*	*Mean*	*SD*			
NCE	47	26.01	6.69			
1-5 years	38	29.32	7.43			
6-10 years	88	28.95	6.79			
> 10 years	81	29.06	6.93			
ANOVA	*Sum of squares*	*df*	*Mean square*	*F*	*P-value*	*Decision*
Between groups	3.46	2	1.73	0.04	0.97	Not Significant
Within groups	9886.72	204	48.46			
Total	9890.18	206				

Source: Authors, July 2025

DISCUSSION

A nation can only harness the full potential of STEM education when a great number of its students have acquired STEM education. Hence, nations and individuals who have recognised the importance of STEM learning have been investing in STEM education for a relatively long time now. However, some nations, especially the developing nations, still seem to lag behind in the teaching of STEM education. Therefore, this study explored STEM teachers' implementation of ISTEME in Nsukka Education Zone, Enugu State, Nigeria, using a quantitative research approach. In addition, the impact of teachers' gender, qualification, and teaching experience on the teachers' teaching of STEM education was examined.

The study's findings indicated a low level of ISTEME implementation in Nigeria. In other words, the teachers generally exhibit the following low implementation behaviours. They do not make the students see the connections between STEM disciplines when delivering instruction. They rarely employ technological resources to deliver STEM-based instruction. They are unable to integrate engineering designs in delivering instruction. They rarely give students project work that challenges them to combine two or more STEM disciplines. They are unable to provide students with opportunities to develop tasks that require a combination of STEM disciplines.

The findings suggest that teachers may focus only on the curriculum content of the subject they teach and pay little attention to STEM education. Furthermore, they pay less attention to how to solve problems using different approaches, carry out investigations, design experiments, analyse data, and draw conclusions using an integrated STEM context. The teachers could not make students' learning of STEM concepts interesting by facilitating collaboration among the students. They also fail to assess their students not only in their subject area but also in relation to their learning of STEM education, and they do not collaborate with colleagues to devise effective ways of integrating STEM education in instruction.

The findings of the study align very well with those of Razal et al. (2022), who reported that STEM education was not implemented on the East Coast of Malaysia because it was not part of the teaching practice of Design and Technology teachers. The findings also corroborated the observation that Mathematics, Science, and Information and Communication Technology teachers were reluctant to implement STEM education (Tunc and Bagceci 2021). Furthermore, the findings support those of Dare et al. (2018), who found that most teachers struggle to implement STEM activities in their classrooms. Several factors could account for these findings. These could range from the teachers' lack of confidence in their ability to implement STEM-based education (Shernoff et al. 2017) and limited knowledge of integrated STEM (Tekin and San 2023). In the Nigerian context, the low teaching of STEM education could be attributed to poor professional development programs aimed at enhancing teachers' knowledge of integrated STEM. In addition, pre-service STEM teachers' programs may still lack integrated content, where STEM disciplines are learned through real-life problem-solving.

The study's findings have significant implications for STEM teachers, government officials at all levels, science textbook authors, curriculum planners, and researchers. The low level of STEM education in Nigeria means that the country is lagging behind in this field. The government at all levels could see through the findings of the study the need to increase the investment in STEM education and also to lay more emphasis on STEM education. The government needs to see the low level of the teaching of STEM education as a government failure in placing STEM education in its rightful position in the Nigerian educational system. The low extent of the teaching of STEM education could also be due to a lack of necessary integrated STEM textbooks that harness STEM principles. Therefore, science textbook authors could, based on the study's findings, see the need to incorporate integrated STEM concepts into their textbooks. Similarly, curriculum planners could also see the need for reforming the science curriculum to accommodate STEM content areas in greater detail.

The findings of the study indicated that gender had no significant impact on teachers' implementation of ISTEME in Nigeria. Of course, with the growing campaign in Nigeria for an increase in women's participation in STEM-related courses, the record of no significant difference in the implementation of ISTEME by male and female teachers may not be surprising. More interestingly, the observation that the general implementation of ISTE-

ME in Nigeria is low suggests that neither male nor female teachers may be implementing STEM education in the first place. Given that both male and female teachers are trained in similar environments and participate in similar programs, one may not expect to see a significant difference in their teaching of STEM education based on gender. Although men still dominate Engineering courses in Nigeria (Orji et al. 2025), the women who teach STEM still match their male counterparts in terms of STEM implementation.

The findings disagree with Idrizi et al. (2023), who found that male students slightly outperformed their female counterparts in STEM online courses. The findings were also not in consonance with Tekin and San (2023), who reported a significant gender difference in students' basic knowledge of STEM in favour of the female group. The disparities in the findings of these studies could be attributed to cultural differences (Alghneimin et al. 2024), as most studies reporting gender differences in STEM were conducted outside Nigeria.

Given the role of qualification in students' learning outcomes, the present study also examined the impact of teachers' qualifications on their teaching of STEM education in Nigeria. The findings revealed that teachers' qualifications play a significant role in the teaching of STEM education in the country, favouring teachers with higher qualifications. This finding is not out of place because the more qualified teachers, especially those with Master's and Ph.D. degrees, have been exposed to advanced content areas in their various subjects as compared to those with basic teaching qualifications like NCE. More qualified teachers are likely to attend seminars, workshops, and conferences, as these also form part of their learning experience during their training. The knowledge they gain from these conferences, seminars, and workshops could give them a greater advantage in implementing STEM education compared to teachers with Bachelor's and NCE degrees. It is expected that secondary school teachers should meet the basic qualification for teaching students before they could be deployed to classrooms. For those with lesser qualifications, they are also expected to update their qualification through participation in refresher packages, especially in the areas of technology adoption.

The findings are in concordance with Tekin and San (2023), who found a significant impact of teachers' qualifications on their basic knowledge of STEM, as well as Tshuma and Maphosa (2025), who emphasized that specialized pedagogical training is a key predictor of STEM literacy. The findings also corroborate those of Syafril et al. (2021), who reported that teachers' quality is fundamental for the effective teaching of STEM education. These studies suggest that teachers at all levels need to have adequate knowledge of STEM education in order to effectively implement STEM-based education. The lack of significant influence of teachers' gender on teachers' implementation of STEM could mean that most of the teachers have inadequate pedagogical knowledge of ISTEME. According to Nguyen et al. (2024), this gap is more or less systemic rather than demographic issue, thereby highlighting the urgent need for training teachers in STEM-based education. Both the teachers and the government may see the need for cooperation, as noted by Ibrahim (2025), to ensure that STEM education in Nigeria meets not only the local needs but also global standards.

The findings of the study indicated that teaching experience had no significant impact on the teachers' implementation of ISTEME. The generally low level of STEM education teaching could account for the lack of a significant role of teachers' years of teaching experience in their implementation of STEM activities. The fact that STEM education seems to be less emphasised in the Nigerian educational system may deter even more experienced teachers from integrating STEM-based activities into their lessons. Moreover, teachers' training programs in Nigerian universities may be lacking on how to integrate STEM education into the individual subject areas, implying that even with more years of teaching experience, the teachers may still be lacking in this area. This finding aligns with Thang's (2021) observation that even teachers with at least five years of teaching experience still encounter significant challenges in teaching STEM education. The findings seem to differ from those of Tekin and San (2023), who found that teaching experience is a major determinant of teachers' basic knowledge in STEM. The impact of teaching experience on STEM education could be more pronounced when there is widespread teaching of STEM education.

CONCLUSION

The study sheds light on the status of Mathematics and Science teachers' implementation of

ISTEME in Nigeria, employing a quantitative research approach. In light of the findings, it is concluded that STEM education in Nigeria is still at a very low stage. In other words, STEM education is not being taught in Nigeria using an integrated approach where students see the connection between STEM disciplines while learning Science and Mathematics. Despite the observation that ISTEME is poorly implemented in the country, teachers' qualification is a significant factor that drives its implementation. However, both teachers' gender and years of teaching experience were not determining factors in teachers' implementation of ISTEME in Nigeria.

RECOMMENDATIONS

In light of the findings of this study, it is recommended that governments should organise workshops and seminars for science and mathematics teachers on how to implement ISTEME. This training needs to be periodically for teachers to continue to update their knowledge on STEM teaching. The governments at all levels should prioritise STEM education by adequately equipping the schools with technological facilities needed for the teaching ISTEME. In addition, Science, Mathematics and Technology teachers should develop collaborative skills to enable them to share knowledge that facilitate the implementation of ISTEME as integrated STEM teaching requires teachers to be versatile. More so, the current secondary school science and mathematics curriculum in Nigeria should be reviewed to give more emphasis on STEM education. It is also suggested that more qualified teachers should be allowed to handle higher classes where more difficult STEM contents are taught.

LIMITATIONS OF THE STUDY

This study, although it revealed that the level of teaching STEM education in Nigeria is low and that teachers' qualifications are a significant factor, the generalisability and interpretation of these findings must consider several limitations. First, the research sample was confined to Mathematics and Science (Biology, Chemistry, and Physics) teachers at Nsukka Education Zone, Enugu State, Nigeria. STEM education is not meant to be implemented solely by science and Mathematics teachers, implying that the teaching of integrated STEM by technology and engineering teachers may differ from that of Science and Mathematics teachers. Consequently, the results may not be applicable to other STEM fields, such as Engineering and Technology, thereby highlighting the necessity for future studies that include broader segments of the STEM teachers' population across different nations.

Secondly, the study was restricted to three teachers' demographic variables, namely, gender, qualification, and teaching experience, implying that the findings should not be generalised to other demographic variables. Moreover, while gender and teaching experience were not significant factors in teachers' teaching of STEM education, this finding could depend on the population of the teachers used. Future researchers should consider replicating this study using observation and interviews as tools for data collection. This replication could also use different STEM teachers from different locations. This would help address the inherent limitations of structured questionnaires, such as faking and forced responses, and contribute to the current research.

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