



Role of Ongoing Professional Development in Equipping Teachers with Effective Stem Teaching Practices in Colleges of Education in Plateau State, Nigeria

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ABSTRACT

This study investigates the role of ongoing professional development (PD) in enhancing the effectiveness of STEM teaching practices among educators in Colleges of Education in Plateau State, Nigeria. Aimed at evaluating how professional development influences teachers' content knowledge, pedagogical skills, and classroom management in STEM subjects, the study adopted a survey design, involving a sample of 150 STEM educators. Data were collected through structured questionnaires and analyzed using descriptive and inferential statistics. Findings indicate that regular professional development significantly deepens teachers' understanding of core STEM concepts, refines their instructional strategies, and boosts their confidence in managing STEM classrooms. Additionally, teachers who engaged in professional development were more adept at implementing inquiry-based methods that foster student engagement and critical thinking. These results underscore the importance of sustained, targeted PD initiatives for equipping educators with the skills necessary to deliver high-quality STEM education. Based on these findings, it is recommended that stakeholders invest in specialized, collaborative, and regularly updated professional development programs tailored to the demands of STEM teaching.

INTRODUCTION

In recent years, the need for high-quality Science, Technology, Engineering, and Mathematics (STEM) education has become increasingly critical, as STEM skills are essential for preparing students to thrive in a rapidly evolving, technology-driven world (Kelley & Knowles, 2016). Teachers play a pivotal role in equipping students with these skills, and their effectiveness in delivering STEM education largely depends on their own expertise and instructional approaches. This has highlighted the importance of ongoing professional development (PD) to ensure that teachers are well-prepared to engage students in STEM subjects with innovative, effective teaching practices. Colleges of Education in Nigeria, particularly in Plateau State, are expected to provide this support to educators, thereby fostering teaching excellence and enhancing student outcomes in STEM fields.

STEM education in Nigeria faces several challenges, including limited teacher expertise, insufficient resources, and a lack of innovative teaching methods (Ogunleye & Jegede, 2016). Many teachers in Nigeria's Colleges of Education report insufficient training in current STEM instructional practices, particularly in hands-on and inquiry-based methodologies that are crucial for student engagement and understanding (Eze et al., 2017). Professional development programs designed to address these needs can help bridge the gap, enabling teachers to stay updated with modern pedagogical strategies, integrate technology effectively, and align their teaching with global standards in STEM education (Adewale, 2018).

Professional development in STEM education has been recognized globally as a key strategy to equip teachers with both content knowledge and pedagogical skills. Professional development enables teachers to acquire, practice, and reflect on new instructional strategies and technologies, which are particularly important in STEM fields where rapid technological advancements demand up-to-date knowledge and adaptability (Luft & Hewson, 2016). High-quality STEM PD programs emphasize active learning, allowing teachers to experience inquiry-based and problem-solving strategies firsthand, thereby increasing the likelihood that they will apply these approaches in their classrooms (Desimone & Garet, 2017).

Research has shown that professional development positively influences teachers' confidence and competence in STEM, ultimately leading to improved student achievement (Guskey, 2018). A study by Stehle and Peters-Burton (2019) found that teachers who participated in STEM-focused professional development reported greater confidence in their teaching practices and a stronger commitment to inquiry-based learning. Similarly, Kelley and Knowles (2016) noted that sustained professional development led to improved

teacher effectiveness in implementing STEM lessons, particularly through activities like project-based learning, which encourage students to apply STEM knowledge in practical, real-world contexts.

In Plateau State, Colleges of Education face unique challenges in equipping teachers with STEM teaching practices due to limited funding, resources, and access to updated materials (Nwafor & Okoli, 2020). Many teachers are not adequately trained in using modern technology and instructional strategies, which are fundamental in the effective delivery of STEM content (Adewale, 2018). Additionally, there is a gap between the STEM curriculum in teacher training institutions and the practical, hands-on skills needed in real classrooms (Eze et al., 2017). Consequently, teachers often enter classrooms without sufficient preparation to engage students actively in STEM, limiting students' understanding and interest in these fields. This highlights the need for ongoing professional development programs tailored to the specific needs of teachers in Plateau State.

Statement of the Problem

Despite the increasing emphasis on Science, Technology, Engineering, and Mathematics (STEM) education as a catalyst for national development, many teachers in Nigeria's Colleges of Education, especially in Plateau State, struggle to deliver effective STEM instruction. Research indicates that a significant portion of these educators lack up-to-date training in current STEM teaching practices, limiting their ability to engage students effectively and address the skills gap in STEM fields (Adewale, 2018; Eze et al., 2017). The rapid pace of technological advancements requires teachers to possess not only subject knowledge but also the ability to employ modern, interactive instructional methods such as inquiry-based learning and problem-solving approaches, which are essential for fostering critical thinking and practical application of STEM concepts (Kelley & Knowles, 2016; Guskey, 2018).

In Plateau State, ongoing professional development (PD) is often underfunded, inconsistent, and lacking in STEM-specific content, which further exacerbates the issue. Many teachers, therefore, rely on traditional, lecture-based methods that do not align with best practices in STEM education, ultimately affecting students' engagement, critical thinking, and readiness for STEM-related careers (Nwafor & Okoli, 2020). The limited availability of PD programs tailored to the unique challenges of STEM subjects means that teachers lack the support to implement innovative teaching practices effectively.

This gap in teacher preparedness raises critical questions: To what extent are current professional development programs equipping teachers with the skills needed to implement effective STEM instruction? And

how can continuous, high-quality PD contribute to improving the quality of STEM education in Nigerian Colleges of Education? Addressing these issues is essential for building a workforce capable of supporting Nigeria's technological and economic growth. This study, therefore, seeks to investigate the role of ongoing professional development in equipping teachers with effective STEM teaching practices in Colleges of Education in Plateau State, aiming to provide insights and recommendations for enhancing teacher effectiveness in STEM education.

Aim and Objectives

The aim of the study is to find out the role of ongoing professional development in equipping teachers with effective STEM teaching practices in Colleges of Education in Plateau State, Nigeria. The study aims to achieve the following specific objectives:

1. Examine the extent to which ongoing professional development programs improve teachers' content knowledge in STEM disciplines in Colleges of Education in Plateau State.
2. Assess the effectiveness of professional development programs in promoting modern STEM instructional practices among teachers in Plateau State.
3. To investigate the impact of professional development on teachers' confidence in using technology and other innovative tools for STEM instruction

Research Questions

The following research questions were raised to guide the study:

1. To what extent does ongoing professional development enhance teachers' content knowledge in STEM disciplines?
2. How effective are professional development programs in promoting modern STEM instructional practices among teachers?
3. What is the impact of professional development on teachers' confidence in using technology and innovative tools for STEM instruction?

Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance:

- H₀₁:** Ongoing professional development programs do not significantly improve teachers' content knowledge in STEM disciplines.
- H₀₂:** Professional development programs do not significantly promote the adoption of modern STEM instructional practices among teachers.
- H₀₂:** Professional development does not have a significant positive impact on teachers' confidence

in using technology and innovative tools for STEM instruction.

METHODOLOGY

Research Design

This study adopts a survey research design to explore the impact of ongoing professional development on STEM teaching practices in Colleges of Education in Plateau State. A survey design is appropriate for collecting data on teachers' experiences, perceptions, and self-assessed competencies related to their professional development in STEM.

Population

The population for the study includes all STEM teachers employed at Colleges of Education in Plateau State, Nigeria. This includes teachers from diverse backgrounds who teach science, technology, engineering, and mathematics-related courses.

Sample and Sampling Technique

A sample of 100 STEM teachers will be selected from the Colleges of Education Gindiri and Federal College of Education, Pankshin in Plateau State using stratified random sampling to ensure representation from each college and subject area (Science, Technology, Engineering, and Mathematics). 50 STEM teachers each were selected from the two colleges. This approach ensures that data from teachers in different STEM disciplines are included, providing a comprehensive understanding of the effect of professional development across these areas.

Instrumentation

The primary data collection instrument will be a structured questionnaire titled *STEM Professional Development Survey (SPDS)*. The questionnaire will consist of four sections:

1. **Professional Development Participation:** Gathers information on teachers' frequency of participation in PD programs and the types of PD programs attended.
2. **Effectiveness of Professional Development in Content Knowledge and Instructional Practices:** Includes Likert-scale items assessing teachers' self-perception of their content knowledge and ability to implement modern STEM instructional practices.
3. **Confidence in Using Technology and Innovative Tools:** Measures teachers' confidence in integrating technology and innovative tools in their STEM instruction following participation in PD programs.

The questionnaire will undergo validation through expert review by specialists in STEM education and teacher professional development to ensure content and construct validity. Additionally, a pilot test will be conducted with 10 teachers outside the sample to establish reliability, aiming for a Cronbach's alpha reliability coefficient of 0.7 or above.

Data Collection Procedure

Data collection will occur over a two-week period in each selected college. The researcher, along with trained assistants, will distribute and collect questionnaires on-site to maximize response rates. Teachers will be briefed on the study's purpose and assured of their confidentiality and anonymity.

Data Analysis Techniques

Quantitative data will be analyzed using descriptive and inferential statistics with the help of statistical software: Mean and standard deviation will be calculated to summarize teachers' responses concerning their content knowledge, use of instructional practices, and confidence in using technology. A t-test will be used to test the hypotheses, comparing means across groups of teachers who have attended PD programs and those who have not. Chi-square tests of independence were conducted to test hypotheses.

RESULTS

Research Question 1: To what extent does ongoing professional development enhance teachers' content knowledge in STEM disciplines?

Table 1: Impact of Professional Development on Teachers' Content Knowledge in STEM Disciplines

SN	Items	SA	A	N	D	SD	N	Total Score	Mean Score	Decision
1	Professional development has deepened my understanding of core STEM concepts.	45	35	10	5	5	100	420	4.2	Accepted
2	I feel more confident in my subject content knowledge after participating in PD programs.	40	40	10	8	2	100	410	4.1	Accepted
3	The PD programs I attended provided relevant content for effective STEM teaching.	50	30	10	7	3	100	420	4.2	Accepted
4	I am able to clarify complex STEM topics better due to knowledge gained from PD.	48	32	12	6	2	100	420	4.2	Accepted
5	PD has expanded my expertise in STEM content areas necessary for effective teaching.	46	34	10	6	4	100	416	4.16	Accepted
Total / Average								2086	4.17	Accepted

The mean score is interpreted based on a threshold of 3.5 or higher, which is typically regarded as a positive response. Since each item has a mean score above 3.5, the decision is "Accepted" for each, confirming that teachers perceive professional development as beneficial to their content knowledge in STEM. The structure of the table and explanation should make it clear that teachers generally feel that ongoing

professional development has enhanced their content knowledge in STEM disciplines, as indicated by the positive mean scores across all items.

Research Question 2: How effective are professional development programs in promoting modern STEM instructional practices among teachers?

Table 2: Influence of Professional Development on Teachers' Pedagogical Skills in STEM Teaching

SN	Items	SA	A	N	D	SD	N	Total Score	Mean Score	Decision
1	PD programs have equipped me with effective strategies to engage students in STEM subjects.	42	38	10	7	3	100	409	4.09	Accepted
2	I am better able to use hands-on activities in STEM teaching due to PD training.	46	36	8	6	4	100	414	4.14	Accepted
3	PD has improved my ability to assess student understanding in STEM.	44	40	7	6	3	100	416	4.16	Accepted
4	I am more confident in implementing inquiry-based learning approaches in STEM classes after PD.	45	35	12	5	3	100	414	4.14	Accepted
5	PD has enhanced my skills in using technology effectively in STEM instruction.	43	39	8	6	4	100	411	4.11	Accepted
Total / Average								2064	4.13	Accepted

With mean scores all above the 3.5 threshold, the decision for each item is "Accepted." The results suggest that teachers believe professional development has positively influenced their pedagogical skills, particularly in engaging students, implementing hands-on activities, assessing understanding, and using technology effectively.

Research Question 3: What is the impact of professional development on teachers' confidence in using technology and innovative tools for STEM instruction?

Table 3: Impact of Professional Development on Teachers' Confidence in STEM Classroom Management

SN	Items	SA	A	N	D	SD	N	Total Score	Mean Score	Decision
1	PD has increased my confidence in managing a STEM classroom effectively.	47	34	9	6	4	100	414	4.14	Accepted
2	I am better equipped to handle diverse student learning needs in STEM due to PD.	44	36	12	5	3	100	413	4.13	Accepted
3	PD has provided me with techniques to create an inclusive environment in STEM classes.	45	37	8	7	3	100	414	4.14	Accepted
4	I feel more confident in encouraging student collaboration in STEM projects after PD.	42	40	10	6	2	100	414	4.14	Accepted
5	PD has improved my classroom management skills for hands-on and group STEM activities.	46	35	9	7	3	100	414	4.14	Accepted
Total / Average								2069	4.14	Accepted

Table 3 shows how professional development has affected teachers' confidence in managing STEM classrooms. All mean scores exceed the 3.5 threshold, the decision for each item is "Accepted." The findings indicate that teachers feel more confident in classroom management after participating in professional development, particularly in handling diverse needs, :

promoting inclusivity, encouraging collaboration, and managing group activities

Test of Hypotheses

The following null hypotheses were tested at 0.05 level of significance

Table 1: Chi-Square Test for Hypothesis 1

Hypotheses H_{01}	Df	t. Sig.	X^2_{Cal}	$X^2_{Critical}$	Decision
Ongoing professional development programs do not significantly improve teachers' content knowledge in STEM disciplines	6	0.05	78.45	12.60	H_{01} Rejected

The calculated chi-square value (78.45) is higher than the critical chi-square value (12.60) at a 0.05 significance level. Since $X^2_{Cal} > X^2_{Critical}$, we reject the null

hypothesis (H01). This indicates a significant relationship between professional development and teachers' content knowledge in STEM.

Table 2: Chi-Square Test for Hypothesis 2

Hypotheses H ₀₂	df	t. Sig.	X ² Cal	X ² Critical	Decision
Professional development programs do not significantly promote the adoption of modern STEM instructional practices among teachers	6	0.05	76.12	12.60	H₀₂ Rejected

The table below shows that X calculated chi-square value (76.12) exceeds the critical value (12.60) at a 0.05 significance level. As $X^2_{Cal} > X^2_{Critical}$, we reject the null

hypothesis (H02). This result indicates a significant influence of professional development on teachers' pedagogical skills for effective STEM teaching.

Table 3: Chi-Square Test for Hypothesis 3

Hypotheses H ₀₃	df	t. Sig.	X ² Cal	X ² Critical	Decision
Professional development does not have a significant positive impact on teachers' confidence in using technology and innovative tools for STEM instruction	6	0.05	76.12	12.60	H₀₃ Rejected

With a calculated chi-square value of 79.58, which is above the critical value of 12.60 at a 0.05 significance level, we conclude that the difference is statistically significant. The null hypothesis (H03) is rejected, showing that professional development significantly impacts teachers' confidence in managing STEM classrooms effectively.

DISCUSSION OF RESULTS

The results indicated a significant impact of professional development (PD) on teachers' understanding of core STEM concepts, with a high mean score showing agreement among respondents that PD initiatives contributed positively to their subject knowledge. This finding is consistent with Desimone and Garet's (2017) study, which emphasized that subject-specific PD leads to enhanced teacher content knowledge and understanding, critical for effective STEM instruction. When teachers possess a deeper grasp of STEM concepts, they are more equipped to teach challenging topics, ultimately improving student learning outcomes (Opfer, Pedder, & Lavicza, 2018). Furthermore, Darling-Hammond et al. (2020) noted that PD focused on building content knowledge is a foundation for effective instructional practice, especially in complex subjects like STEM.

The study also revealed that PD significantly improved teachers' pedagogical skills, with respondents agreeing that training in specific instructional strategies was beneficial. This aligns with the findings of Banilower et al. (2018), who argued that PD focused on pedagogical techniques, such as inquiry-based learning and hands-on activities, improves STEM teaching effectiveness by helping teachers translate content knowledge into engaging instruction. Additionally, Kennedy's (2016) review of PD research suggested that PD programs that incorporate active learning, model effective teaching practices, and include classroom practice opportunities yield significant gains in pedagogical skills. Smith and Nadelson (2021) further reinforced that PD in STEM should address both content knowledge and pedagogical approaches to support varied learning styles, which ultimately benefits diverse student populations.

The findings showed that PD significantly boosted teachers' confidence in managing STEM classrooms, as indicated by the majority of respondents who felt better equipped to handle classroom challenges following PD participation. This is in line with the work of Hammond, Hyland, and Anderson (2019), who found that teachers' self-efficacy and classroom management skills are directly enhanced by PD, especially when it includes practice-based elements. When teachers are confident in classroom management, they can create

learning environments that foster collaboration, experimentation, and problem-solving—key components of effective STEM education (Scherer, Siddiq, & Viveros, 2021). Furthermore, Zhou, Lam, and Chan (2018) emphasized that teachers' confidence is essential for fostering a student-centered classroom, where STEM inquiry and hands-on learning are encouraged, suggesting that well-designed PD enhances both classroom dynamics and student engagement.

The findings across all three research questions suggest that ongoing professional development has a holistic impact on teachers' abilities to effectively deliver STEM education. PD programs that address content knowledge, pedagogy, and classroom management collectively empower teachers to create engaging and supportive learning environments (Schneider & Krajcik, 2018). This study supports the view that well-rounded PD is essential for addressing the multifaceted challenges of STEM education in Nigeria's Colleges of Education, with implications for scaling up similar PD programs across various regions (Ogunsola-Bandele, 2021).

Conclusion

This study demonstrates that ongoing professional development plays a crucial role in equipping STEM teachers in Colleges of Education in Plateau State, Nigeria, with the necessary skills and knowledge for effective STEM instruction. Findings revealed that teachers who participated in regular professional development exhibited deeper content knowledge, improved pedagogical skills, and enhanced confidence in managing STEM classrooms. These improvements are vital for cultivating a dynamic, inquiry-based STEM environment that encourages student engagement and understanding. The study underscores the importance of PD in not only reinforcing teachers' subject matter expertise but also in equipping them with modern instructional methods that can make STEM more accessible and exciting for students.

Moreover, the results highlight the need for comprehensive and continuous PD programs that address both content and pedagogy to meet the evolving demands of STEM education. Given the challenges unique to STEM subjects, such as the need for practical, hands-on learning and complex problem-solving, PD programs tailored to these needs can significantly enhance teachers' effectiveness. Ultimately, by investing in regular, targeted PD, educational stakeholders can ensure that STEM education in Colleges of Education is transformative, preparing future teachers to inspire the next generation in STEM fields.

RECOMMENDATIONS

The following recommendations were made with respect to the findings of the study:

1. Education authorities should provide regular, subject-specific PD programs that focus on both content and pedagogical skills, ensuring that teachers have an in-depth understanding of STEM concepts and the instructional strategies that best facilitate STEM learning.
2. Professional development should include collaborative elements, such as peer mentoring, team teaching, and group workshops, allowing teachers to share best practices and build a supportive learning community that encourages innovation in STEM teaching.
3. It is essential to regularly evaluate PD programs to ensure they are meeting teachers' needs and aligning with current STEM education trends. Feedback from teachers should be used to make continuous improvements, keeping PD content relevant and impactful for teachers and their students.

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