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STEM TEACHERS' EFFECTIVENESS AS CORRELATES OF SECONDARY SCHOOL STUDENTS' SCIENCE PERFORMANCE IN MINNA EDUCATIONAL ZONE, NIGER STATE, NIGERIA

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Abstract

This study investigated STEM teachers' pedagogical knowledge and pedagogical content knowledge as correlates of secondary school students' science performance in Minna Educational Zone, Niger State. The study adopted correlational research design, the population of the study was 1204 science teachers in 160 secondary schools in Minna Educational Zone of Niger State. Three hundred (300) science teachers were selected using a simple random sampling technique. The instrument for data collection was a 4-point scale questionnaire that measured teachers' pedagogical content knowledge. The instrument was validated by two experts in science education. The questionnaire was pilot tested and was analysed using Cronbach alpha and the data yielded a reliability coefficient of 0.74. The data were analysed using linear regression to test the formulated hypotheses. The findings showed a significant positive association between Pedagogical knowledge and pedagogical content knowledge and students' performance in science. It was recommended among others that workshops and professional capacity training should be regularly organised to improve STEM teachers' pedagogical practices, among others.

Keywords: *Pedagogical Knowledge, Pedagogical Content Knowledge, STEM Teachers and Students Performance*

Introduction

Effective science teaching has a crucial role in shaping the future development of any society. Science education, therefore, has become an essential prerequisite for a thriving economy, especially with the emerging global economy. Many industrial nations seek to improve the quality of science education because of the vital role Science and Technology play in a nation's economy and in the standard of life. A new way of teaching and learning about science reflects how science is done because it emphasizes inquiry to achieve knowledge and understand the world. In addition, to having the ability to learn and teach science, teachers also need to possess both theoretical and

practical knowledge. In recent years, the quality of scientific teacher preparation programs and their connection to raising the standard of education systems, in general, have drawn significant attention from the public on a global scale. Making science more accessible to students, easier to learn and retain, and reflective of real scientific activity is a key goal of science education. Thus, ensuring the future and raising the standard of science education require science teacher preparation. Today, almost no one disputes the idea that science teachers impact students' learning outcomes.

The poor performance of students in science could be attributed to several factors such as lack of motivation for students, poor infrastructural facilities, and the attitude of students and teachers toward learning (Ekpen, 2020). Likewise, another element influencing science teachers' pedagogical approach is the shortage of possibilities for their professional growth. Motivation, orientation, self-esteem, and learning styles are important elements that affect academic achievement. The increasing popularity of motivation among educational psychologists has led to the possibility of manipulating other variables to enhance academic achievement. Additionally, pupils' academic performance in terminal and sessional examinations has been impacted by their disinterest in certain science courses (Ntibi, 2017). Additionally, Cornelius-Ukpepi (2020) mentioned that textbooks, lab equipment, and other learning resources could contributes significantly to students' performance in science sessional and terminal examinations. The authors added that students' low academic achievement is mostly caused by teachers' low pedagogic content knowledge. Likewise, another element influencing science teachers' pedagogical approach is the lack of possibilities for their professional growth, training, and retraining.

Perhaps a productive path to travel is what Shulman (1986) has labeled Teachers Pedagogical and Content Knowledge (TPACK). While Content Knowledge refers to one's understanding of the subject matter, pedagogical knowledge refers to one's knowledge of teaching and learning processes independent of the subject matter, Teachers' pedagogical and content knowledge refers to knowledge about the teaching and learning of particular subject matter that takes into account the specific learning demands inherent in the subject matter (Shulman 1986 & Jacob, 2020). Much has been written about the nature and development of TPACK and one of the main ideas is that TPACK is a personal construct, and a teacher's years of experience is predicted to be very important in the development of TPACK meaning that each teacher could develop their own TPACK over the years of teaching (Jacob, 2020). A teacher's pedagogical and content knowledge level determines how efficient he is in transferring knowledge in the best possible way that his students will understand. Therefore, TPACK is necessary for the effective achievement of educational goals because teachers are indispensable in the academic structure, for they are the life wire of education.

Pedagogical Content Knowledge (PCK) plays a vital role in classroom instruction. It is an academic term that describes several interconnected domains of knowledge that are useful to the teacher teaching in a school or an out-of-school context. The most important domains are subject-specific content knowledge and knowledge of the pedagogy used in teaching a subject. A PCK involves teachers' competence in delivering the conceptual approach, relational understanding, and adaptive reasoning of the subject matter in the teaching and learning process. Without a full grasp of PCK, teachers may face difficulty in teaching the subject effectively, leading to either misconceptions or lack of understanding that will be evident in students' performance over time. Studies have shown that the development of pedagogical and content knowledge is critical for the educator. Teachers should be knowledgeable in the content areas and pedagogy for which they are responsible to teach, without this, the students may face difficulty in their learning. Furthermore, the study article has shown that improving teachers' PCK could improve teachers' instructional practices, and consequently, students' academic performance.

Shulman's conceptualization of PCK is the notion of transforming the subject matter

for teaching. Specifically, according to Shulman (1987), this transformation occurs as the teacher interprets the subject matter, finds multiple ways to represent it, and adapts and tailors the instructional materials to alternative conceptions and students' prior knowledge. PCK covers the core business of teaching, learning, curriculum, assessment, and reporting, such as the conditions that promote learning and the links among curriculum, assessment, and pedagogy. An awareness of common misconceptions and ways of looking at them, the importance of forging connections among different content-based ideas, students' prior knowledge, alternative teaching strategies, and the flexibility that comes from exploring alternative ways of looking at the same idea or problem are all essential for effective teaching.

Shulman had now presented what he considered to be the seven fundamental areas of teacher knowledge. It was then that the term 'pedagogical content knowledge (PCK) explicitly stood out as a construct of particular value. In the words of Shulman (1987), pedagogical content knowledge is of special interest because it identifies the distinctive bodies of knowledge for teaching. It represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners and presented for instruction. Pedagogical content knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue.

Gusti, et al, (2019), examined the relationship between Pedagogical Content Knowledge (PCK), and Content Knowledge (CK) and their impact on students' mathematics achievement. The results showed that both CK and PCK had a positive relationship with students' mathematics achievement. Campbell et al (2014) reported that there is a strong positive relationship Regarding the relationship between CK and PCK knowledge of secondary school teachers, it was found that there was a very strong relationship with student achievement. Similarly, Raimundo et al (2014) conducted a study on teachers' pedagogical content knowledge and its relation with students' understanding. They reported a positive correlation between teachers' PCK and students' achievement in mathematics. Michael et al (2022) investigated Teachers' Pedagogical Knowledge and Mathematical Skills as Predictors of Students' Achievement in the New Normal in Tagum city in the Philippines. The findings show a positive association between teachers' pedagogical knowledge and students' performance. These studies were conducted outside the population of this study; therefore, the findings of this study could yield important data that will have implications for effective science instruction and capacity training for science teachers.

Statement of the Problem

Globally there is a quest for effective and meaningful learning in the classroom at all levels of education. However, there are growing concerns in the education industry regarding the quality of teachers' and students' performance. The success or failure in teaching can be attributed to several factors (school, students, and teachers' factors) and one of the important teachers' factors is the pedagogical approach or pedagogical and content knowledge. For effective and meaningful instruction to take place in the classroom, the teacher must not only have a good mastery of the subject matter, but pedagogical knowledge, pedagogical and content knowledge, and proper knowledge of classroom management (Jacob *et al,* 2020). Therefore, the level of science Teachers' Pedagogical and Content Knowledge (TPACK) could impact the quality of teaching and learning science. Consequently, teachers with high TPACK could influence effective learning while teachers with low TPACK could struggle to influence meaningful learning. Pedagogical Content Knowledge (PCK) plays a vital role in classroom instruction. PCK involves teachers' competence in delivering the conceptual approach, relational understanding, and adaptive reasoning of the subject matter in the teaching and learning process.

Ramos (2020) in his research on PCK and students' achievement in Chemistry concluded that teachers who possess high TPACK were able to produce students with

high academic performance in Chemistry. Meanwhile, Jacob (2020) investigated teachers' pedagogical and content knowledge as a determinant of academic performance in secondary schools and the results revealed that the teacher quality was high and there was an average level of students' academic performance in secondary schools. Therefore, teacher quality and academic qualification had no significant influence on students' academic performance. Given the gap in the literature and the inconclusiveness of findings on the relationship between science teachers' PK, PCK, and science students' performance, Hence, this study investigates Science teachers' pedagogical and content knowledge as Correlates of secondary school chemistry students' academic performance in Minna metropolis Niger state.

Research Questions

The following research questions were raised to guide the study:

1. What is the relationship between science teachers' pedagogical knowledge and science students' academic performance in Minna Metropolis, Niger state?
2. What is the relationship between science teachers' pedagogical and content knowledge and Science students' academic performance in Minna Metropolis, Niger state?

Null Hypotheses

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

HO_1: There is no significant relationship between science teachers' pedagogical knowledge and Science students' performance.

HO_3: There is no significant relationship between science teachers' pedagogical and content knowledge and Science students' performance.

Research Method

This study employed a correlational research design to establish the relationship between two or more variables. Seeram (2019) describes correlational research design as non-experimental research that facilitates prediction and explanation between variables. The population of the study was one thousand two hundred and four (1204) science teachers in one hundred and sixty (160) secondary schools in Minna Educational Zone of Niger State. The zone is made up of six Local government areas. The simple random sampling technique was adopted to select three hundred (300) science teachers for the study using the Krejcie and Morgan Table. The simple random sampling technique offers all subjects from the population equal chances of being selected for examination.

The instrument used for data collection is a researcher-developed Questionnaire on science teachers' Pedagogical and Content Knowledge as Correlates of Secondary School Science Students' Performance in Minna metropolis, Niger state (QSTPACK). The questionnaire consists of five-point Likert-type questions. In addition, the questionnaire comprises of three sections A to C.

Section A contains demographic information of the respondents, section B consists of fifteen items that solicit science teachers' opinions on Pedagogical Knowledge (PK) amongst science teachers, and section C consists of fifteen items on Pedagogical and Content Knowledge (PCK). The questionnaire is a 4-point scale which includes: Strongly Agree (SA), Agree (A), Disagree (DA), and Strongly Disagree (SD) with a scale of 4, 3, 2, and 1. The instrument was validated by 2 experts in science education, there observations and recommendations were used to improve the instrument. The aggregate score of students' performance in science; biology, chemistry, and physics was obtained which served as the criterion variable. The questionnaire was pilot tested and was analysed using Cronbach alpha and the data yielded a reliability coefficient of 0.74. This shows that this instrument is reliable (Tang, *et al* 2014)

The researchers visited the schools sought for the consent of the respondents and briefed them on the objectives of the study. The questionnaire was administered to the respondents with help of research assistants and the data obtained were analysed using the scattered plot to answer the research questions

and linear regression to test the formulated hypotheses using Statistical Package foe Social Sciences (SPSS) 25.

Results

The results are presented based on the stated research question and the formulated hypotheses.

Research Question 1: What is the relationship between science teachers' pedagogical knowledge and science student' academic performance in Minna Metropolis, Niger state? To answer this research question, scattered plot was used and the results presented in Figure 1

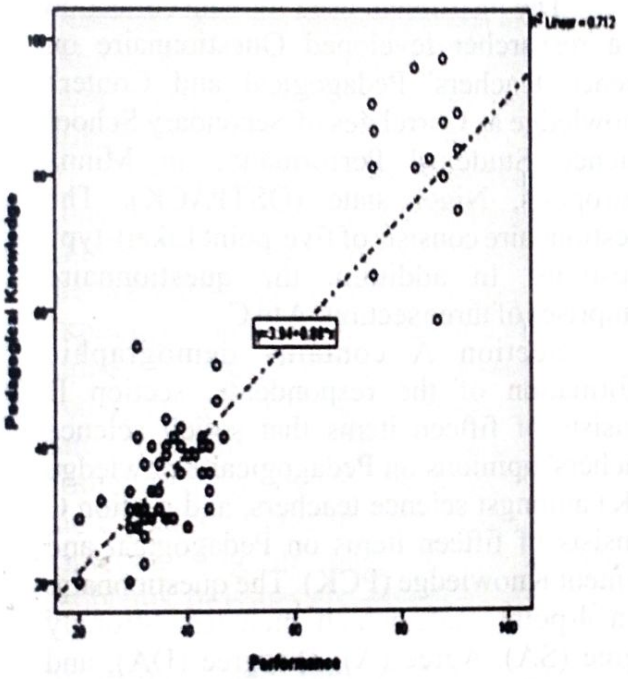

Figure 1: Scattered Plot of the Relationship Between Science Teachers' PK and Students' Performance in Science

Figure 1 shows a Scatterplot showing the relationships between pedagogical knowledge and students' performance in science. The scattered plot indicates that there is a positive relationship between the pedagogical knowledge and students' performance in science as indicated by the regression line. Therefore, linear regression will be used to determine the strength of the relation.

Research question 2: What is the relationship between science teachers' pedagogical and content knowledge and Science students' academic performance in Minna Metropolis, Niger state? To answer this research question, scattered plot was used and the results presented in Figure 1

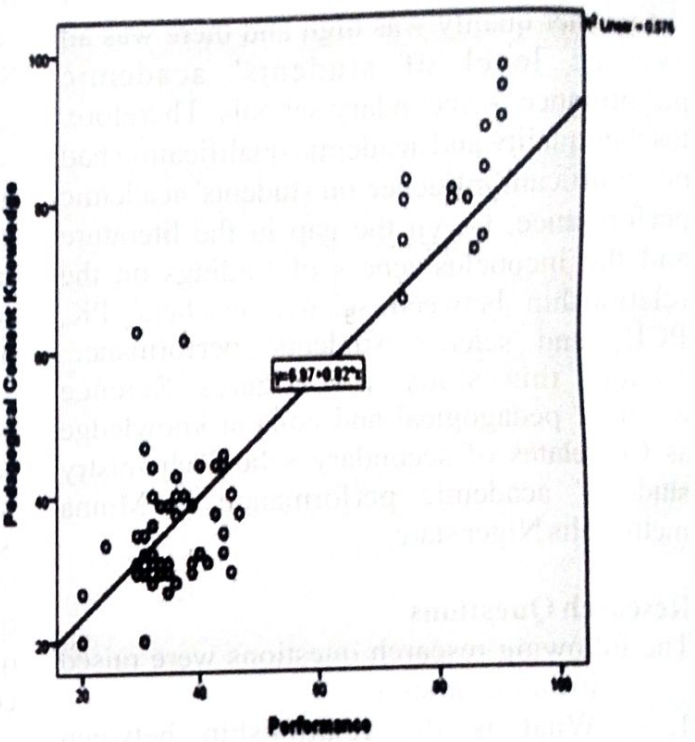

Figure 2: Scattered Plot of the Relationship Between Science Teachers' PK and Students' Performance in Science

Figure 1 shows a Scatterplot showing the relationships between Pedagogical Content Knowledge and students' performance in science. The scattered plot indicates that there is a positive relationship between the pedagogical Content knowledge and students' performance in science as indicated by the regression line. Therefore, linear regression will be used to determine the strength of the relation.

Hypothesis 1: There is no significant relationship between science teacher pedagogical knowledge and students' performance in science. To test this formulated hypothesis, linear regression was used, and the results presented in Table 1

Table. 1: Linear Regression Model Summary on the Relationship Between Science Teacher Pedagogical Knowledge and Students' Performance in Science

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.844[a]	.712	.711	6.442

a. Predictors: (Constant), Pedagogical Knowledge

Table 1 shows that r (2,308) = .844, r^2 = .712. This indicates that 71.2% of the variance in students' performance in science can be explained by teachers' pedagogical knowledge in the Minna educational zone. The regression coefficient is presented in Table 1b

Table 2: Linear Regression Coefficient between Teacher Pedagogical Knowledge and Students' Performance in Science

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	7.526	1.158		6.501	.000
	Pedagogical Knowledge	.813	.030	.844	27.172	.000

a. Dependent Variable: Performance

Table 1 that teachers' pedagogical knowledge is a significant predictor of students' performance in science (B = .844, t = 27.17, p(0.00) < 0.05). The finding indicates that the standardized Beta coefficient for PK is positive and statistically significant. Therefore, the hypothesis is rejected. The regression coefficient indicates that for any increase in one unit of PK will cause an increase of 0.813 units of students' performance in science when all other factors are constant in this population.

Hypothesis 2: There is no significant relationship between science teachers' pedagogical and content knowledge and Science students' performance. To test this formulated hypothesis, linear regression was used, and the results presented in Table 2

Table 3: Linear Regression Model Summary on the Relationship Between Science Teacher Pedagogical Content Knowledge and Students' Performance in Science

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.759[a]	.576	.575	7.818

a. Predictors: (Constant), Pedagogical Content Knowledge

Table 3 shows that r (2,308) = .759, r^2 = .576. Indicating that 57.6% of the variance in students' performance in science can be explained by teachers' pedagogical content knowledge in the Minna educational zone. The regression coefficient is presented in Table 2b

Table 4: Linear Regression Coefficient between Teacher Pedagogical Content Knowledge and Students' Performance in Science

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	10.903	1.387		7.860	.000
	Pedagogical Content Knowledge	.704	.035	.759	20.139	.000

a. Dependent Variable: Performance

Table 4 shows that teachers' pedagogical content knowledge is a significant predictor of students' performance in science ($B = .759$, $t = 20.139$, $p(0.00) < 0.05$). The finding indicates that the standardized Beta coefficient for PCK is positive and statistically significant. Therefore, the hypothesis is rejected. The regression coefficient indicates that any increase in one unit of PCK will cause an increase of 0.704 units of students' performance in science when all other factors are constant in this population.

Discussion of Findings

The finding showed that there is a significant positive relationship between teachers' pedagogical knowledge and students' performance in science. This finding agrees with the earlier results of Michael et al (2022) investigated Teachers' Pedagogical Knowledge and Mathematical Skills as Predictors of Students' Achievement in the New Normal in Tagum City in the Philippines. The findings show a positive association between teachers' pedagogical knowledge and students' performance. On the contrary, Joshua & Oluwatoyin (2017) carried out correlation research on pedagogical and content knowledge as a determinant of students' performance in Edo state and reported that pedagogical and content knowledge had no significant influence on students' academic performance.

The finding also showed that there is a significant positive relationship between teachers' pedagogical and content knowledge and students' performance in science. This finding agrees with the earlier results of Ramos (2020) in his research on PCK and students' achievement in Chemistry concluded that teachers who possess high PCK were able to produce students with high academic performance in Chemistry. Meanwhile, Jacob and Gwani (2020) investigated teachers' pedagogical and content knowledge as a determinant of academic performance in secondary schools and the results revealed that the teacher quality was high and is associated with an average level of student's academic performance in secondary schools. This finding suggests that to improve students' performance in science, teachers' pedagogical knowledge and pedagogical and content knowledge should be enhanced through professional capacity building

Conclusion

Given the findings of this study, it will be logical to conclude that Teachers' pedagogical knowledge and their pedagogical content knowledge are positively associated with students' performance in science. It would be logical to conclude that to improve students' performance in science, teachers' pedagogical knowledge and pedagogical and content knowledge should be enhanced. This suggests that one cannot give what he does not have. Therefore, it was recommended that workshops and professional capacity training should be regularly organised for teachers to bridge the gap between theory and practice.

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