INFLUENCE OF TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE ON SENIOR SECONDARY STUDENTS' INTEREST AND PERFORMANCE IN ALGEBRA

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Abstract

This study examined influence of Mathematics teachers' pedagogical Content Knowledge (PCK) on Senior Secondary Students' interest and Performance in Algebra in Benue State, Nigeria. Three research questions and three null hypotheses guided the study. Eclectic approach design was adopted where various research approaches blended together were used individually or collectively focusing on some aspects of the research. A sample of six Mathematics teachers were drawn out of 48 Mathematics teachers from senior secondary schools using multistage sampling technique while 200 SSI students were drawn from the intact classes found under the six mathematics teachers. Data were collected from the six mathematics teachers using Mathematics Teachers Algebra Lesson Plan Protocol Rating Scale (MTALPPRS), Mathematics Teachers Algebra Pedagogical Content Knowledge Classroom Observation Rating Scale (MTAPCKCORS) and Mathematics Teachers Algebra Teaching Questionnaire (MTATQ). Other instruments include; SSI Mathematics Curriculum, Textbooks and scheme of work which were analysed to ascertain the level of Teachers' Pedagogical Content Knowledge. Data from students were derived using Students' Algebra Interest Questionnaire (SAIQ) and Students' Algebra Performance Test (SAPT). The reliability coefficient of SAIQ 0.89 was realized using Cronbach alpha while SAPT 0.92 was realized using Pearson moment Correlation. Mean and standard deviation were used for answering the research questions, while Analysis of Covariance (ANCOVA)was used for testing the hypotheses. The results revealed that there is significant difference in the mean interest rates of SSI students taught algebra by Mathematics teachers with high and low level PCK in favour of those taught algebra by mathematics teachers with high PCK. However, there is no significant difference in the mean performance scores of SSI students taught algebra by mathematics teachers with high and low level PCK. Findings on gender revealed no significant difference in the mean performance scores of male and female SSI students taught algebra by mathematics teachers with high and low level PCK. Based on the findings, it was recommended among other things that Mathematics teachers should aspire to have high level pedagogical content knowledge to be able to generate and sustain students' interest in algebra. Mathematics teachers should strive to possess the required pedagogical content knowledge to enhance students' high performance in algebra.

Keywords: Teachers' Pedagogical Content Knowledge, Students, Interest, Performance, Algebra

Introduction

Given the importance of Mathematics to humanity in all spheres of life, government of the Federal Republic of Nigeria (FRN, 2014), like all other governments in the world, has made it a core subject right from the primary to secondary school levels even at tertiary education levels, mathematics is a requirement to several undergraduate courses and most postgraduate courses. In the same vein Norris (2018) stresses that the core nature of mathematics as a school subject has given it a gatekeeper statue into higher education requiring a credit pass in Mathematics to guarantee candidates' admission. Relatedly, Hom and Gordon (2021) posit that Mathematics is at the heart of science and our daily lives. Mathematics is the gateway to many scientific and technological fields. Taking the subject for granted limits students' opportunities to learn a range of important subjects thus inhibiting their future opportunities and depriving society of potential pool of quantitatively literate citizens (Li & Schoenfeld, 2019).

Despite the importance and core nature of mathematics in schools, the teaching of Mathematics has consistently yielded poor performance in mathematics both at internal and external examinations (Usman & Musa, 2019).Similarly, the west African examination council (WAEC) chief examiner's report for 2018 revealed mass failure in mathematics with candidates demonstrating major weakness in algebra especially their inability to translate word problems into mathematical statements and solve them. Algebra is a branch of mathematics in which symbols usually letters of alphabets represent numbers or numbers of specified set are used to represent quantities and to express general relationship that hold for all elements of a set (Dogo Kyeleve & Kurumeh, 2017). It is also seen as a branch of mathematics dealing with symbols and the rules for manipulating those symbols, in elementary algebra, those symbols written as Latin and Greek letters represent quantities without fixed values known as Variables (Coolman, 2015). Algebra is an important life skill, it helps develop critical thinking skills in areas of problem solving, logic, pattern and reasoning.

Poor performance in school algebra specifically and Mathematics generally are attributed to the following: acute shortage of professional mathematics teachers, exhibition of poor knowledge of Mathematics content by mathematics teachers, continuous over use of conventional teaching methods, students' negative attitude towards Mathematics and undue emphasis on syllabus coverage at the expense of meaningful learning (Zakariya, 2014; Suleman & Abdullahi, 2016; Bello & Musa, 2017).

Disparity in performance among gender in Mathematics and specifically algebra has been blamed on the instructional approaches, lack of expertise, teachers' experience, qualification and students' interest (Alio, Iyoke & Kevin, 2019). This is found evident in the results obtained from the findings of Ajai and Imoko (2015), Iji, Hommane & Omenka (2016) and Saddiq, Salman and Adeniji (2017) which revealed there is no significant difference between the mean achievement scores of male and female students in their studies, in the contrary, the studies of Tsebo and Kurumeh (2014), Anigbo and Ndukwe reported that male students

performed higher in Mathematics than female students.

According to Odili (2006) in Omoroh (2017) for the teaching and learning of Mathematics to be sustainable in the interest of learners, the teacher must possess a substantial amount of the subject matter, content knowledge also known as pedagogical content knowledge. Teachers' mathematical knowledge is key to students' sustainable achievement in mathematics. The success or failure in the process of teaching a concept in mathematics is the function of the teaching style/strategy adopted by the teacher. One of the qualities of a good Mathematics teacher is effectiveness in delivery of a lesson which depends on the pedagogical content knowledge of the teacher (Sibuyi, 2012).

Similarly, Kyeleve (2009) and Muhammed and Yusha (2017) explained that good subject knowledge coupled with pedagogical content knowledge, the conception and preconception teachers have about and towards mathematics determines how they design and implement classroom instruction. All these form Integra parts of the National Policy on Education (FRN 2014) which indicates that "the attainment of any teaching objective depends on the teachers' knowledge, motivational power, dedication to work, experiences, educational qualification, mastery of the subject matter, lesson preparation and personality among others". It is in the light of the above that the researcher sought to investigate the level of mathematics teacher's pedagogical knowledge content and it influence on students with respect to interest and performance in algebra.

Agwagah (2013) defines pedagogical content knowledge as the knowledge about how to teach in a particular discipline rather than only knowledge of a particular subject matter. Shulman (1986) the pioneer of the kind of knowledge a teacher needs to posses to provide effective instruction in the classroom opines that pedagogical content knowledge is the way of representing and formulating the subject in such a way that make it comprehensible to others, an understanding of what makes the learning of specific topics easy or difficult, the conception and preconception that students of different ages and background bring with them to the learning of those most frequently taught topics and classroom discourse. Shulman, initially address teachers' knowledge in three dimensions namely; content knowledge, curriculum knowledge and pedagogical content knowledge while in 1987 he developed new model by increasing the number to seven categories of teachers' knowledge viz: subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge and knowledge of learners and learning, others include; curriculum knowledge of educational context and knowledge of educational philosophies, goals and objectives.

A more comprehensive model was later proposed by Hashweh (2005) which consist of eight dimensions of teachers' knowledge namely: knowledge of purpose, knowledge of learners, curriculum knowledge, knowledge of instructional strategies and resources, knowledge of measurement and assessment, content knowledge, knowledge of context and knowledge of pedagogy. These components of teachers' knowledge proposed above moved the researcher to investigate the level of mathematics teachers' knowledge and its

influences on senior secondary students' interest and performance in algebra.

Students' interest in algebra could enhance performance in Mathematics generally. Ugbodum (2017) in Tali and Dogo (2019) posit that interest increases students' success in learning task. it is a preference for particular types of activities which is likely or prone to seek out and participate in learning the tasks. Harackiewicz, Smith and Priniski (2016) define interest as an individual's momentary experience of being captivated by object(s) as well as more lasting feelings that the object is enjoyable and worth further exploration. Similarly, Ugbodum (2017) in Tali and Dogo (2019) state that interest in mathematical activities tend to increase the likely hood that individuals formulate goals relating to mathematical activities and invest more efforts to achieve. It is an important variable that may enhance or decline learners' performance. In view of the above, it has become necessary for Mathematics teachers to acquire and practice appropriately their pedagogical content knowledge in Mathematics classroom so as to generate and sustain students' interest in learning mathematics particularly algebra to improve positive performance in mathematics examination.

Statement of the Problem

The prevalent poor performance of students in both internal and external mathematics examination has become a source of major concern for Mathematics educators, parents, the public, government and other stake holders. For most students are unable to read, write, understand and interpret mathematical problems or solve them correctly, many still see no need using symbols as they remain abstract and meaningless to them. This is indicated in the WAEC Chief examiner's report (2018-2020). As a results, most of the students do not attend, per attention or actively participate in mathematics lessons which implies lack of interest in learning Mathematics thus leading to poor performance. The poor performance in mathematics, denial candidates' opportunities to gain admission into tertiary institution of learning and so many brighter opportunities in the future.

Teachers' pedagogical content knowledge appears to be wanting in promoting effective teaching and learning of algebra as portrayed by the persistent poor performance of candidates and even those who gain good grades after examinations cannot defend their good grades this is evident in their performance in the tertiary institutions. Do majority of the teachers understand, state, and make known to their students the quantifiable objectives intended to achieve? Do teachers take into cognizance learners' prior knowledge, developmental stage, needs, difficulties, misconceptions/errors and interest? To what extent do Mathematics teachers create a conducive algebra learning environment as well as challenge students' cognitive ability using innovative and appropriate instructional strategies and resources? To what extent do Mathematics teachers' level of pedagogical content knowledge in the classroom minimize or eradicate gender disparity in performance? In view of the foregoing, the researchers found out the level of Mathematics teachers' pedagogical content knowledge and its influence on students' interest and performance in algebra.

Purpose of the Study

The main purpose of the study is to examine the influence of Mathematics teacher's pedagogical content knowledge on senior secondary students' interest and performance in algebra in Benue State Nigeria. Specifically, the objectives were to:

(1) Determine the level of Mathematics teachers' pedagogical content knowledge influence on SSI students' interest in Algebra.
(2) Ascertain the level of Mathematics teachers' pedagogical content knowledge influence on SSI students' performance in Algebra.
(3) Investigate the mean performance of male and female SS1 students taught algebra by Mathematics teachers with high and low level PCK.

Research Questions

The following research questions were answered in this study:

(1) What are the mean interest rates of SSI students taught algebra by Mathematics teachers with high and low level PCK?
(2) What are the mean performance scores of SSI students taught algebra by Mathematics teachers with high and low level PCK?
(3) What are the mean performance scores of male and female SSI students taught algebra by Mathematics teachers with high and low level PCK?

Hypotheses

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

H0$_1$ There is no significant difference between the mean interest rates of SSI students taught algebra by Mathematics teachers with high and low levels of pedagogical content knowledge.

H0$_2$ There is no significant difference between the mean performance scores of SSI students taught algebra by Mathematics teachers with high and low levels of pedagogical content knowledge.

H0$_3$ There is no significant difference in mean performance scores of male and female SS1 students taught algebra by Mathematics teachers with high and low levels of pedagogical content knowledge.

Research Method

Eclectic approach design was adopted for the study. This is a design where various research approaches are blended together and may be used individually or collectively, focusing on some aspects of the research study. The various approaches include pre- and post-test administered before and after instruction to ascertain whether a difference exists in students' performance scores when taught algebra by Mathematics teachers with high and low level pedagogical content knowledge. A descriptive survey design was adopted as well where students' interest rate data were collected before and after the teaching session by Mathematics teachers with high and low level pedagogical content knowledge using questionnaire. A case study design was carried out were Mathematics teachers were observed and rated during their lessons. Document analysis such as Mathematics curriculum, scheme of work, lesson plan, and text books used were done. The objective of this research is to determine if the level of teachers' pedagogical content knowledge influence students' interest and performance in algebra.

The study was conducted on senior secondary school students in Katsina-Ala Local Government Area, Benue State Nigeria. The population of the study was 48 Mathematics teachers and 10,567 SSI students at the time of the study. The sample of the study was six Mathematics teachers and 200 SSI students drawn from intact classes under the six Mathematics teachers from six senior secondary schools selected via multistage sampling technique. Mathematics Teachers' Algebra Lesson Plan Protocol Rating Scale (MTALPPRS), Mathematics Teachers' Algebra Pedagogical Content Knowledge Classroom Observation Rating Scale (MTAPCKCORS) and Mathematics Teacher's Algebra Teaching Questionnaire (MTATQ) were used for collection of data. MTALPPRS, MTAPCKCORS, MTATQ and SAIQ passed through face validation, while SAPT underwent face and content validation. SAIQ was found to be highly reliable with the reliability coefficient of 0.87 obtained using cronbach Alpha (Salkind, 2015), while the reliability coefficient of SAPT 0.92 was obtained using Pearson Product Moment Correlation (Omenka, 2011).

The researchers and the five research assistants employed also known as observers, for observing and rating for the algebra class sessions. The study lasted for 10 weeks. Mean and standard deviation were used for answering the research questions; while Analysis of Covariance (ANCOVA) was used for testing the hypotheses at 5% alpha level.

Research Question 1: What are the mean interest rates of SS1 students taught algebra by Mathematics teachers with high and low level pedagogical content knowledge?

The summary data of the students' interest rating is provided in Table 1.

Table 1: Mean Interest Rates of Students Taught Algebra by Mathematics Teachers with High and Low Levels of Pedagogical Content Knowledge

PCK Level	N	Pre-SAIQ Mean	S.D	Post-SAIQ Mean	S.D	Gain
High	113	2.02	.74	3.68	.59	1.66
Low	87	1.83	.67	3.50	.35	1.67
□ difference		0.19		0.18		-0.01

Table 1 reveals the mean interest rate and standard deviation of SS1 students taught algebra by Mathematics teachers with high level PCK of 2.02 and .74 at pre-SAIQ while 3.68 and .59 at post-SAIQ. The mean interest rate of SS1 students taught algebra by Mathematics teachers with low level PCK reveals 1.83 and .67 at pre-SAIQ while 3.50 and .35 at post-SAIQ respectively, yielding a mean difference of .19 and .18 at pre-SAIQ and post-SAIQ respectively. The mean gain of -0.01 is in favour of those taught by mathematics teachers with low PCK and it is indeed negligible.

Research Question 2: What are the mean performance scores of SS1 students taught algebra by Mathematics teachers with high and low level of PCK?

Table 2: Mean Performance Scores of SS1 Students Taught Algebra by Mathematics Teachers with High and Low Level PCK

PCK Level	N	Pre-SAPT Mean	S.D	Post-SAPT Mean	S.D	Mean Gain
High	113	21.77	9.38	28.14	14.36	6.37
Low	87	12.53	7.66	19.66	9.91	7.13
difference		9.24		8.48		-0.76

Table 2 reveals the mean performance scores and standard deviation of SS1 students taught algebra by Mathematics teachers with high level PCK are 21.77 with 9.38 and 28.14 with 14.36 at pre-SAPT and post-SAPT respectively, with 6.37 as the mean gain while the mean performance scores and standard deviation of SS1 students taught algebra by Mathematics teachers with low level PCK are 12.53 with 7.66 and 19.66 with 9.91 at pre-SAPT and post-SAPT respectively showing the mean gain of 7.13. The mean difference scores between SS1 students taught algebra by Mathematics teachers with high and low level PCK are 9.24 and 8.48 at pre- and post-SAPT yielding a mean gain of -0.76 signifying a negative mean gain. This mean gain is in favour of students taught algebra by Mathematics teachers with low level PCK.

Research Question 3: What are the mean performance scores of male and female SS1 students taught algebra by Mathematics teachers with high and low level PCK?

Table 3: Mean Performance Scores of Male and Female SS1 Students Taught Algebra by Mathematics Teachers with High and Low Level PCK

Gender	N	Pre-SAPT Mean	S.D	Post-SAPT Mean	S.D	Mean Gain
Male	98	16.48	10.01	23.27	13.89	6.79
Female	102	18.97	9.89	25.59	12.63	6.62
difference		- 2.49		-2.32		0.17

Table 3 reveals that the pre- SAPT and post- SAPT SS1 female students' mean performance scores were higher than the pre-SAPT and post- SAPT of SS1 male which gave

a mean difference of -2.49 and -2.32 respectively. However, the overall mean gain of male and female SS1 students is 0.17 indicating a small mean difference between male and female performance scores in favour of the males.

Hypothesis 1: There is no significant difference between the mean interest rate of SS1 students taught by Mathematics teachers with high and low levels of PCK.

Table 4: ANCOVA Results of Mathematics Teachers' PCK level on SS1 Students' Interest Rate in Algebra

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7.192	2	3.596	15.991	.000	.140
Intercept	233.833	1	233.833	1039.776	.000	.841
Pre-SAIQ	5.468	1	5.468	24.313	.000	.110
PCK Level	.974	1	.974	4.330	.039	.022
Error	44.303	197	.225			
Total	2645.944	200				
Corrected Total	51.495	199				

a. R Squared = .140 (Adjusted R Squared = .131)

b. Completed using alpha = 0.05

Table 4 shows $F_{(1,197)} = 4.33$ with p value 0.039 as $p = 0.04 < 0.05$ indicating there is a significant difference in the mean interest rate of SS1 students taught algebra by Mathematics teachers with high and low level PCK. From the same table, the effect size value .022 which is 2.2% shows that only 2.2% of the SS1 students' interest rate is attributed to the post-instructional effect indicating a small effect size in the students' interest rates. Therefore, the null hypothesis is rejected.

Hypothesis 2: There is no significant difference between the mean performance scores of SS1 students taught algebra by Mathematics teachers with high and low levels of PCK.

Table 5: ANCOVA Results of Mathematics Teachers' PCK level on SS1 Students' Performance Scores in Algebra

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9791.084	2	4895.542	38.122	.000	.279
Intercept	6582.742	1	6582.742	51.26	.000	.206
Pre-SAPT	6250.974	1	6250.974	48.677	.000	.198
PCK Level	239.414	1	239.414	1.864	.174	0.09
Error	25298.416	197	128.418			
Total	154650.00	200				
Corrected Total	35089.500	199				

a. R Squared = .279 (Adjusted R Squared = .279)

b. Completed using alpha = .05

Table 5 shows that $F_{(1,197)} = 1.864$ and a p value of 0.17 which is not significant since p = 0.17 > 0.05, this indicates that there is no statistically significant difference in the mean performance scores of SS1 students' taught algebra by Mathematics teachers' with high and low levels of PCK. From the same table, 0.09 = 9% effect size in respect of SS1 students' performance scores are attributed to the post-instructional effect signifying a small effect size in the students' performance scores that is attributed to the Mathematics teachers' PCK level. Therefore, the null hypothesis is not rejected.

Hypothesis 3: There is no significant difference in the mean performance scores of male and female SS1 students taught algebra by Mathematics teachers with high and low level pedagogical content knowledge.

Table 6: ANCOVA Results of PCK Level and Students' Gender on Students' Performance Scores in Algebra

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10380.800[a]	4	2595.200	20.481	.000	.296
Intercept	7098.979	1	7098.979	56.025	.000	.223
Pre-SAPT	6183.601	1	6183.601	48.801	.000	.200
PCK Level	174.959	1	174.959	1.381	.241	.007

Gender	4.602	1	4.602	.036	.849	.000
Gender*method	587.166	1	587.166	4.634	.033	.023
Error	24708.700	195	126.711			
Total	154650.000	200				
Corrected Total	35089.500	199				

a. R Squared = .296 (Adjusted R Squared = .281)

Table 6 shows that $F_{(1,195)} = 0.036$ with p = .85. Since p = 0.85 > 0.05, there is no significant difference in the mean performance of SS 1 male and female students taught algebra by Mathematics teachers with high and low levels of PCK. The effect size .000 = 0% indicating that there is no variance in the mean performance scores of SS I male and female students taught algebra attributed to Mathematics teachers PCK level. Therefore, the null hypothesis is not rejected.

Discussion of Findings

The result indicated a significant difference in favor of the students taught algebra by mathematics teachers' with high PCK level. That is students taught algebra by mathematics teachers with high level of pedagogical content knowledge had higher interest rates than those taught by mathematics teachers with low level pedagogical content knowledge, hence the null hypothesis was rejected. This finding is line with Jega and Julius (2018); Terna and Boyle (2017); Rabiu and Saidu (2018) and Usman and Musa (2019) who examined and reported that students taught by mathematics teachers with a high level of academic qualification and experience, knowledge of motivation, teaching method, interest and instructional materials are indicators of mathematics teacher with high level pedagogical content knowledge. This indicates that, mathematics teachers' pedagogical content knowledge influence students' interest rates in mathematics, specifically in algebra.

The effectiveness in teaching of teachers with high PCK level which affected students' interest rates positively could be attributed to the teachers' level of motivation, reinforcement, teacher, and students' level of interaction in and outside the classroom. Teachers' mastery of subject matter (algebra content) and above all teachers' knowledge of students in algebra which encompasses teachers' knowledge of students' prior knowledge, difficulties, misconceptions/errors, learners' developmental stage, needs, abilities, interest and creating a conducive environment for teaching and learning of algebra alongside providing enjoyable and engaging learning experiences. These factors are anchored on the behaviorist theory of learning which stresses on creating an enabling environment for learning to take place as well as reinforcement as a reward for a good behavior so that such behavior would be repeated on and on.

The finding also showed no significant difference in the mean performance scores of SS1 students taught algebra by Mathematics teachers with high and low level pedagogical content knowledge indicate that both teachers' level influence students' performance at equal rate. Therefore, the level of Mathematics teachers' pedagogical content knowledge is not a major factor in influencing performance in algebra. Hence, the null hypothesis was not

rejected. This finding agrees with Odumosu, Olisama and Areelu (2018), Suharta and Parwati (2018), Shittu and Sulaiman (2019), who examined influence of teachers' basic abilities, content, and pedagogical knowledge on students' achievement in Mathematics and reported that there was no significant difference or relationship between the mean performance scores of students taught algebra by mathematics with high and low level PCK.

However, Olasehinde, Yahaya and Owolabi (2018), Olfos, Goldrine and Estrella (2014), Lange kleickiman and Moller (2012), Jega and Julius (2018), and Usman and Musa (2019) reported that there was a significant difference in the mean performance scores of students taught algebra and Mathematics generally with different PCK levels in their study. The no significant difference in the mean performance scores could be attributed to the following: readiness on the part of students to learn, fear and anxiety of writing or being tested, poor study habits, retention and transfer of algebra knowledge, time specified for the study, choices of options due to guess work. It might also be that teachers exposed students to relevant and adequate algebra activities on the topics, marked assignments submitted, gave corrections to misconceptions/error observed just to mention a few.

The result of gender on mean performance scores of SS 1 students taught algebra by Mathematics teachers with high and low level PCK was not significant. This means that there was no gap between male and female SS 1 performance scores. This study is in line with Odomusu, Olisma and Areelu (2018) whose finding revealed that there is no significant difference in the mean performance scores of male and female students in algebra when exposed to teachers' content and pedagogical knowledge. This result could be attributed to the fact that both teachers with high and low level PCK were gender sensitive while teaching the students algebra and that both male and female were motivated to work hard.

Conclusion

Based on the findings of this study, it was concluded that Mathematics teachers with high pedagogical content knowledge influence positively students' interest rates in algebra than those taught with low level PCK. However, there is no significant difference in the mean performance scores of SS 1 students taught algebra by Mathematics teachers with high and low level PCK. There was also no significant difference in the mean performance scores of male and female SS 1 students taught algebra by mathematics teachers with high and low level PCK that is, gender disparity is highly minimize.

Recommendations

Based on the findings and conclusion of this study, the researchers recommended the following:

1. Mathematics teachers should aspire to have high level pedagogical content knowledge to be able to generate and sustain students' interest in algebra.
2. Mathematics teachers should strive to possess the required pedagogical content knowledge to enhance students' performance in algebra
3. Mathematics teachers should use their level of PCK to provide an enabling teaching and learning environment that is gender sensitive and promote

active participation by male and female students in algebra lessons so as to eliminate disparity in gender performance scores.

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