

REPOSITIONING PRE-SERVICE MATHEMATICS TEACHER PREPARATION AND PROFESSIONAL DEVELOPMENT IN NIGERIA: AN ANALYSIS OF THE CURRICULUM OF MATHEMATICS TEACHER EDUCATION IN THE LEARNING AND TEACHING OF JSS MATHEMATICS METHOD COURSES

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Abstract

Mathematics teachers do rely on mathematics knowledge for teaching when enacting the work of teaching mathematics. What teachers know, how they know and how they use what they know, are all embedded in the mathematics knowledge for teaching and it is an important determinant of teacher competency when considering mathematics teachers' likelihood for success in the classroom. The purpose of this study was to assess selected Lagos State pre-service mathematics teachers' mathematics content knowledge and mathematical pedagogical content knowledge. The study was guided by three research questions. The sample consisted of eight-six year two pre-service mathematics teachers representing two Ogun State colleges of Education. The instrument used was Mathematics Knowledge for Teaching JSS Mathematics Contents. Data were analysed using descriptive statistics and Pearson's Product Moment Correlation. Respondents' content knowledge and pedagogical content knowledge revealed levels of "adequacy" in four of the six themes of the Junior Secondary Schools Mathematics Curriculum. However, they had low levels of content knowledge and pedagogical content knowledge in Algebra and Function and Geometry and Measurement. A moderate positive association existed between overall pre-service teachers' content knowledge and pedagogical content knowledge, supporting previous research. The findings indicated that pre-service teachers need additional preparation in the six themes essential to every junior secondary school mathematics education classroom. Additional research in pre-service teacher content knowledge and pedagogical content knowledge is recommended to identify teaching strategies that could positively affect the less-than-desired levels of content knowledge and pedagogical content knowledge for state-mandated junior secondary schools mathematics curriculum.

Keywords: *mathematics knowledge, content knowledge, pedagogical content knowledge,*

Introduction

The level of performance of a student in a given mathematical task reflects the level of such student mathematical knowledge. The importance of mathematical knowledge cannot be overemphasized not only because it helps individuals to think critically and creatively but also because mathematics knowledge helps in taking decisions that require precision. Despite these values, Mathematics as a subject in school is disliked by many students despite the fact that it is the bedrock of science and social science subjects and adequate knowledge in it boosts reasoning faculty of students (Brown, Brown & Bibby, 2008). Mathematics concepts seem like daunting tasks for many students and experience has shown that students' difficulties and lack of understanding of mathematics cannot solely be attributed to students own limitations alone.

Teachers' mathematical knowledge could have influences on students' achievement in mathematics. Studies have shown that, it is only few teachers that are aware that students sometimes over-generalize what they learn about some mathematical concepts and that could cause them to make errors in the learning of successive mathematical concepts (Park &

Oliver, 2007; Zuya, 2014). In mathematics classroom, the mathematics teacher makes students to have the discerning mind to appreciate, identify and be able to solve problems. Mathematics teacher also apply multiple approaches or methods which could enhance meaningful understanding of the subject and promote students' algebraic procedural and conceptual development (Cankoy & Darbaz, 2010). Successful application of these multiple approaches could directly impact on students' creativity, enhance students' access to important mathematics concepts, and gradually uplifts students mind from basic challenges to higher order (Otun, 2017). Mathematics teachers discover mathematically promising students, students who are mathematically creative and with higher order thinking skills. Deep understanding of mathematics concepts involves several domains of mathematical knowledge. Teachers acquire these domains of mathematical knowledge from teaching and other experiences outside the classroom. These domains of mathematical knowledge could influence how teachers act with students in the classroom as they engage students in studying mathematics. When teachers possess these right sorts of knowledge, their interventions in the classroom lead to greater students' achievement and when teachers do not possess this sort of knowledge, their students' achievement suffer (Ball, Hill, & Bass, 2005; Akinsola, 2013). One of the roles of a teacher's mathematical knowledge for teaching is the ability to be able to interpret and translate difficult and complex mathematical concepts to the level appropriate to the learning experiences of the students (Otun, 2017). This is one of the major reasons for the call on teachers' updating their mathematical knowledge and acquaintance with the prevailing teaching strategies which could enhance meaningful understanding of mathematical concepts and which are student-centred.

There is a growing recognition that more research is necessary to explore pre-service teachers' mathematical knowledge in the field of mathematics education, because it is very paramount to promote such knowledge at different levels of education (Carraher & Schliemann, 2007; Kieran, 2007; Filloy, Rojano & Puig, 2008; Ake, Godino, Gonzato & Wilhelmi, 2013; Zuya, 2014). One of the aims of mathematics teachers training programme in Nigerian Colleges of Education is to develop pre-service mathematics teachers' subject-matter knowledge and pedagogical content knowledge (NCCE, 2009). Pre-service mathematics teachers are exposed to the teaching and learning of Universal Basic Education Mathematics Curriculum through the junior secondary school (JSS) mathematics content courses (NCCE, 2009). These JSS mathematics method courses are meant to develop the pre-service teachers' subject-matter knowledge and pedagogical content knowledge. These courses are meant to equip them with different approaches or methods of teaching some difficult Mathematics concepts and student thinking processes. Despite the fact that pre-service teachers are exposed to these method courses, the challenges pre-service teachers are facing during teaching practice showed that pre-service teachers are still weak in mathematical algebraic knowledge for teaching (Bolaji, 2005; NCCE, 2009; Ashikhia, 2010; Bessong, Ubana, & Udo, 2013).

If the goal of effective instructional strategies is to improve students' scores in mathematical concepts, then there is need for a shift from teacher-centred approach of teaching and learning mathematics. Khazanov (2007) argued that most teacher educators do not apply students-centred and activity-based approaches while teaching pre-service teachers and they do not allow them to plan and present this method while in training. These gaps are more visible when these pre-service teachers are employed to teach mathematics, they teach the way they were taught. Student-centred and activity-based strategies are numerous

amongst which are: problem solving, demonstration; drill, field trip, experimental, guided discovery method, laboratory, reflection and problem posing. Studies have shown that problem solving; reflective activities and problem posing strategy involve rich repertoires of activities, skills and strategies for teaching mathematics (Cankoy & Darbaz 2010).

For Nigeria to produce mathematically creative problem solvers, mathematics teachers must serve as the catalysts to create mathematical classrooms. To achieve these mathematically creative classrooms, one might look at the pre-service teachers that would shape the students of tomorrow. The dilemma at hand, according to the literature, is twofold. First, pre-service teachers have weak mathematical knowledge for teaching (Blanton & Kaput, 2005; Asquith, Stephens, Knuth, & Alibali, 2007; Stephens, 2008; Akinsola, 2009). Secondly, pre-service teachers' have inadequate knowledge of students errors and misconceptions (Asquith, Stephens, Knuth & Alibali, 2007; Ake, Godino, Gonzato & Wilhelmi, 2013; Depaepe, Verschaffel, Kelchtermans, 2013).

There are many studies on pre-service teachers knowledge for teaching (Asquith, Stephens, Knuth, & Alibali, 2007; Ball, Hill, & Bass, 2005; Batanero and Diaz, 2011; Depaepe, Verschaffel, Kelchtermans, 2013), pre-service teachers knowledge of students (Baker & Chick, 2006; Chick, Baker, Pham & Cheng, 2006; Salman, 2008) and pre-service teachers problem posing ability (Cankoy, & Darbaz, 2010). There are not much success recorded so far in the development and testing new teaching strategies that aid, impact and improve the domains of algebraic knowledge for teaching, enhance the knowledge of students algebraic thinking processes of pre-service teachers' and their problem posing skills in the Nigerian colleges of education.

Statement of the Problem

Teachers' mathematical knowledge could improve or hinder the achievement of students in mathematics. Teachers' knowledge about teaching and learning has been cited as the most important predictor of students' success (Greenwald, Hedges & Laine, 1996). Furthermore, teacher's mathematical knowledge and their ideologies influence students' mathematical learning and values, which permit students to engage or not to engage in a mathematics course (Lannin, Webb, Chval, Arbaugh, Hicks, Taylor, & Bruton, 2013). It is important to consider the level and the depth of mathematics content knowledge and mathematical pedagogical content knowledge of pre-service mathematics teachers. Moreover, despite these numerous studies conducted on mathematical knowledge needed for teaching, there is still lack of detailed understanding of pre-service teachers' achievement in JSS mathematics.

The purpose of this study

The primary purpose of this study is to gather empirical evidence about pre-service mathematics teacher preparation for primary and lower secondary classes.

The questions that guided this study are:

1. What is the level and depth of the mathematics content knowledge attained by pre-service junior secondary school mathematics teachers expected to enable them to teach the kind of demanding mathematics curriculum currently found in the junior secondary schools?
2. What is the level and depth of the mathematical pedagogical content knowledge attained by pre-service junior secondary school mathematics teachers expected to enable them to teach the kind of demanding mathematics curriculum currently found in the junior secondary schools?

3. Determine if associations existed between pre-service teachers' mathematics content knowledge and mathematical pedagogical content knowledge for each of six themes of junior secondary school knowledge and skill area objectives

2. Literature Review

Theoretical and Empirical Frameworks

It is the combination of knowledge derived from different sources that contributes to the development of knowledge for teaching. According to Shulman (1986) teachers gain their knowledge for teaching from four sources; scholarship in content disciplines, educational materials and structures, formal educational scholarship and the wisdom of practice. The pre-service mathematics teachers need to be engaged in several categories of knowledge in order to impact meaningfully and successfully mathematics education on those students they will be teaching in the nearest future. Shulman (1986) provided a framework to analyse teachers' mathematical knowledge. He proposed an in-depth look at what pre-service mathematics teachers must know in order to teach, highlighting that pre-service mathematics teachers need to be prepared to be able to transform that subject matter content through teaching strategies to make that knowledge accessible to learners.

To teach, pre-service teachers need to have developed an integrated knowledge structure that incorporates knowledge about subject matter, learners, pedagogy, curriculum, and schools; they need to have developed a pedagogical content knowledge (PCK), for teaching their subjects. Shulman (1986) proposed pedagogical content knowledge in 1985, as well in many different subject areas, pedagogical content knowledge has been the backbone of a theoretical framework for research into what pre-service mathematics teachers should know.

In his first study as related to teacher's knowledge in 1986, Shulman first identified three categories related to teacher content knowledge: subject matter content knowledge, curricular content knowledge, and pedagogical content knowledge. His idea, termed pedagogical content knowledge (PCK), has since been developed by many researchers and, in the context of mathematics, encompassed into what is known as Mathematical Knowledge for Teaching (MKT). Shulman (1987) later specified seven categories of a knowledge base for teaching, and these are: knowledge of content; knowledge of curriculum; pedagogical content knowledge; knowledge of pedagogy; knowledge of learners and learning; knowledge of contexts of schooling; and knowledge of educational philosophies, goals, and objectives. He and his colleagues argued that content knowledge component includes both the amount of the subject knowledge as well as the organizing structure of the subject (Shulman, 1986, 1987; Grossman, Wilson, & Shulman, 1989). This content knowledge is beyond knowledge of the facts or concepts of a domain.

Curriculum knowledge is the second category. It consists of knowledge of different programs and corresponding materials available for teaching the given content. It goes beyond an awareness of the different programs and materials to also include knowledge of the effectiveness and implications of programs and materials for given contexts. It entails knowledge of content and corresponding materials in other subject areas of students' and consists of knowledge of how topics are developed across a given program (Shulman, 1986). Pedagogical content knowledge is the third category. This knowledge is the category most likely to distinguish the understanding of the content specialist from that of the pedagogue (Shulman, 1987). Pedagogical content knowledge includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that

students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons.. The initial call by Shulman (1986) launched scholars' efforts to specify what body of knowledge is required for teaching. Recently, researchers differed in their definitions of the term pedagogical content knowledge and referred to different aspects of subject matter knowledge for teaching, which seems to have undermined its usefulness (Ball, Thames, & Phelps, 2008).

Several other scholars have attempted to identify components of teacher mathematics knowledge (Grossman, 1990; Marks, 1990; Fennema & Franke 1992; Ma, 1999). In their various studies, they all proposed their own model of teachers' mathematics knowledge. Their suggested model managed to identify some aspects of mathematical knowledge necessary for teaching. In elaborating on Shulman's construct of PCK, several research teams (Ball, Thames & Phelps, 2008; Hill, Ball & Schilling, 2008) use a construct which maps their domains of content knowledge for teaching onto two of Shulman's (1986) initial categories for PCK, those of subject matter knowledge and pedagogical content knowledge. However, Ball et Al. (2008) developed a practice-based theory of teachers' mathematical knowledge for teaching and have been experimentally testing the components of their framework. Ball and her colleagues created the term "mathematical knowledge for teaching" (MKT) to refer to a special kind of knowledge required only for teaching mathematics (Hill et al., 2005; Ball et al., 2008).

To more effectively categorize the types of thinking and knowledge that constitute MKT, Ball et al. introduce several sub-domains, which lie on a continuum from subject matter knowledge to pedagogical content knowledge. MKT consists of two domains: subject matter knowledge (SMK) and pedagogical content knowledge (PCK). Both of these are further divided into three sub-domains. SMK consists of: common content knowledge (CCK) refers to general knowledge of mathematics; specialized content knowledge (SCK) is specific to mathematics teaching. It is used when students' solutions, explanations and reasoning are assessed; and knowledge at the mathematical horizon (KMH) which means relations between concepts and topics included in the mathematics curriculum. PCK is divided into: knowledge of content and students (KCS) means understanding students' mathematical thinking; knowledge of content and teaching (KCT) deals with the ability of teacher to choose and arrange suitable problems for the classroom; and knowledge of curriculum (KC).

While the goal of teaching is to enable students to use mathematical constructs comfortably and apply mathematical strategies confidently without worrying overtly about why they work, the teacher must worry about such things so that they can "make features of particular content visible to and learnable by students" (Ball et al., 2008). They illustrate the difference between CCK, SCK, and KCS: Recognizing a wrong answer is common content knowledge (CCK), whereas sizing up the nature of an error, especially an unfamiliar error, typically requires nimbleness in thinking about numbers, attention to patterns, and flexible thinking about meaning in ways that are distinctive of specialized content knowledge (SCK).

Various studies conducted by other researchers have demonstrated that teaching mathematics demands mathematical understanding beyond the mathematical knowledge needed by other practitioners of mathematics. In addition, findings of other studies have contributed to the notion that majoring in mathematics or having strong subject matter content knowledge is insufficient for the mathematical knowledge necessary for teaching (Ball, Hill, & Bass, 2005; Hill, Ball, & Schilling, 2008; Hill, Rowan, & Ball, 2005).

Teachers' knowledge about teaching and learning has been cited as the most

important predictor of students' success (Greenwald, Hedges & Laine, 1996; Zepa & Kajander, 2009). Furthermore, teacher's conceptual understanding of mathematics and their ideologies influence students' mathematical learning and values, which permit students to engage or not to engage in a mathematics course (Bishop, Clarke, Corrigan & Gunstone, 2006). It is important to consider how teachers' mathematical knowledge (knowledge of mathematical concepts and procedures) and values (mathematical conceptions and ideologies) influence students' mathematical knowledge and learning (Ambrose, 2004).

It is important to consider the level and the depth of mathematics content knowledge and mathematical pedagogical content knowledge of pre-service mathematics teachers. Moreover, despite these numerous studies conducted on mathematical knowledge needed for teaching, there is still lack of detailed understanding of pre-service teachers' achievement in JSS mathematics.

3. METHODOLOGY

A descriptive-correlation design (Field, 2000) was used to determine pre-service teachers' mathematics content knowledge and mathematical pedagogical content knowledge levels for each of the six themes of Lagos State Junior Secondary School Mathematics Curriculum. The target population included all the second year Nigerian Colleges of Education pre-service mathematics teacher preparation programmes. The accessible population included all second year pre-service mathematics teachers in two Colleges of Education in Ogun State.

The study involved eighty-six year two pre-service mathematics teachers from two colleges of education in Ogun state. The colleges of education selected involved a federal and a state college of education. The sample size was not too large in order to observe these subjects during their classes. The researcher tried to ensure that the subjects were representative of the pre-service teachers who majored in mathematics and who have undergone the initial levels of pedagogical content knowledge. Sample from the first school is 42 (male = 20 and female = 22), second school sample is 44 (male = 21 and female = 23). These participants were chosen because these pre-service mathematics teachers' were assumed to have possessed appreciable knowledge of mathematics and also pedagogical skills that might have equipped them with mathematical knowledge needed for teaching at the primary and lower secondary school levels. Secondly, this set of pre-service mathematics teachers' have been prepared for first teaching practice, that is, field experience. They were also readily available for the study unlike third year pre-service teachers who were writing their final year projects and were on teaching practice. Moreover, the second year pre-service teachers have been introduced to mathematics contents method courses and problem solving strategy unlike year one pre-service teachers who were yet to be exposed to necessary method courses and year three pre-service were busy with their project work.

Research Instrument

An instrument was used in the study. The instrument is Mathematics Knowledge for Teaching JSS Mathematics Contents (MKMC).

Development of the Research instruments

Mathematics Knowledge for Teaching JSS Mathematics Contents (MKMC)

Mathematics Knowledge for Teaching JSS Mathematics Contents (MKMC) was used to find out the level of pre-service teachers mathematical knowledge on six selected JSS mathematics concepts. The Mathematics Knowledge for Teaching JSS Mathematics Contents

(MKMC) instrument was designed to assess the pre-service teachers' mathematics content knowledge (based on the state assessment items from the Lagos State Junior School Mathematics Certificate Examination). The Lagos State Junior School mathematics Examination covered the standard content stipulated in the federal and states' curricula for Junior Secondary Schools one to three mathematics curriculum. The paper-and-pencil test used to assess pre-service teachers mathematical knowledge consisted of forty open ended questions derived from the Lagos State Junior School Mathematics Examination 2012 to 2014 past questions. The Lagos State Junior School Mathematics Examination assessment is used to measure a student's attainment of the mathematics academic standards and it also determines the admission of such student into Lagos State Senior Secondary school.

The assessment of mathematics content knowledge measured six domains: number and operations (7 questions), geometry and measurement (10 questions), algebra and functions (10 questions), everyday statistics (5 questions), probability (8 questions) and trigonometry (5 questions). The test for mathematical pedagogical content knowledge was developed by the researcher and measured three domains: curricular knowledge, knowledge of students, and knowledge of enacting teaching. The test was designed to take up to 60 minutes to answer under a controlled administration.

The items in the instrument covered mathematical topics that are compulsory for basic seven to nine and that are particularly appropriate for assessing the mathematics content knowledge and mathematical pedagogical content knowledge of mathematical content. The questions in the instrument are related to all areas of junior secondary school mathematics including: number and operations (7 questions), geometry and measurement (10 questions), algebra and functions (10 questions), everyday statistics (5 questions), probability (8 questions) and trigonometry (5 questions). The state examination board confirmed that all items were tested for reliability and validity for use in the state examinations. For the purpose of the study, three formations of word problems questions which were not available in the Lagos State Junior School Mathematics Examination were included.

The Mathematics Knowledge for Teaching JSS Mathematics Contents (MKMC) required the pre-service teachers to solve the questions correctly. A panel of two mathematics educators and two JSS mathematics teachers reviewed the items on the instrument for content validity. Each member of the panel reviewed the questions to assure that correct answers existed and the questions were stated clearly. The panel suggested eliminating the multiple-choice answers to avoid opportunity for responses that would not require guessing. The panel also suggested eliminating some of the problems that were redundant. The instrument was then given to sixteen pre-service mathematics teachers. The responses were scored and the reliability coefficient of the MKMC was determined using test re-test method. It was found to be 0.72. The Mathematics Knowledge for Teaching JSS Mathematics Contents (MKMC) items are sampled items junior secondary school three students in Lagos State are assessed on. Their use in this study was to determine the extent to which college of education pre-service mathematics teachers are competent with the subject-matter content knowledge. The argument here is that pre-service teachers should be knowledgeable about the content they are to teach.

4. Method of Data Analysis

Findings should be generalized only to the participants group ($N = 86$). Descriptive statistics were calculated to describe the respondents. Bivariate analyses were used to describe

relationships between pre-service teachers' mathematics content knowledge and mathematical pedagogical content knowledge for the junior secondary school mathematics curriculum objectives. Relationships between variables with continuous scores were analyzed using Pearson's product moment correlations and measures of association were described using the standards established by Davis (1971).

Research Question 1: What is the level and depth of the mathematics content knowledge attained by pre-service junior secondary school mathematics teachers expected to enable them to teach the kind of demanding mathematics curriculum currently found in the junior secondary schools?

Table 1: Summary of Mean Mathematics Content Knowledge (MCK) and Mathematical Pedagogical Content Knowledge (MPCK) Levels by JSS Mathematics Objective (N = 86)

	N	Mean	Std. Deviation
Algebraic content knowledge	86	26.7791	2.33843
Geometrical content knowledge	86	26.9279	2.88218
Numerical content knowledge	86	89.7442	17.71618
Trigonometric content knowledge	86	79.8023	2.02815
Probability content knowledge	86	86.1512	9.25650
Statistical content knowledge	86	75.4419	12.20666
Algebraic pedagogical content knowledge	86	25.6744	3.01932
Geometrical pedagogical content knowledge	86	50.6744	16.67012
Numerical pedagogical content knowledge	86	81.3953	1.77087
Trigonometric pedagogical content knowledge	86	61.1395	13.11054
Probability pedagogical content knowledge	86	81.4767	15.99097
Statistical pedagogical content knowledge	86	66.4651	18.57747
Valid N (listwise)	86		

Low = 0 – 39; Average = 40 – 49; Adequate = 51 – 69; Very Adequate = 70 – 80; Sufficient = 81 – 100

The descriptive analyses in Table 1 revealed that the level and depth of numerical content knowledge (Mean=89.74, Standard Deviation=17.72) and probability content knowledge (Mean=86.15, Standard Deviation=9.26) attained by pre-service junior secondary school mathematics teachers is sufficient enough to enable them to teach these topics in the junior secondary schools. The pre-service teachers demonstrated very adequate trigonometric content knowledge and statistical content knowledge (M=79.80), (M=75.44) respectively, but they demonstrated low levels (M =26.93), (M=26.78) of geometrical content knowledge and algebraic content knowledge respectively, to enable them satisfactorily teach these topics in the junior secondary schools.

Research Question 2: What is the level and depth of the mathematical pedagogical content knowledge attained by pre-service junior secondary school mathematics teachers expected to enable them to teach the kind of demanding mathematics curriculum currently found in the junior secondary schools?

Furthermore, the descriptive analyses in Table 1, also revealed the level and depth of numerical pedagogical content knowledge (Mean=81.40) and probability pedagogical content knowledge (Mean=81.48) attained by pre-service junior secondary school mathematics teachers is sufficient to enable them to teach these topics in the junior secondary schools. The pre-service teachers demonstrated adequate statistical pedagogical content knowledge, trigonometric pedagogical content knowledge and geometrical pedagogical content knowledge with the following average mean scores (M=66.47), (M=61.14) and (50.67)

respectively, but they demonstrated low level ($M = 25.67$) of algebraic pedagogical content knowledge respectively, to enable them satisfactorily teach these topics in the junior secondary schools.

Research Question 3: Determine if associations existed between pre-service teachers’ mathematics content knowledge and mathematical pedagogical content knowledge for each of six themes of junior secondary school knowledge and skill area objectives

Table 2: The Overall Scores of Mathematics Content Knowledge and Mathematical Pedagogical Content Knowledge of Pre-Service Teachers

	Mean	Std. Deviation	N
MCK	383.5465	22.66360	86
MPCK	285.3488	24.96669	86

Adequate = 200 – 299; Very Adequate = 300 – 399; Sufficient = 400 – 499

To complete the third objective, pre-service mathematics teachers’ mathematics content knowledge and mathematical pedagogical content knowledge levels were summed, revealing the mean and standard deviation of “adequacy” in mathematics content knowledge as compared to their mathematical pedagogical content knowledge attained by pre-service junior secondary school mathematics teachers expected to enable them to teach the kind of demanding mathematics curriculum currently found in the junior secondary schools. See (Table 2). The sum of pre-service mathematics teachers score in mathematics content knowledge revealed that they are “adequate mathematical content knowledge ($Mean = 383.55$ $SD = 22.66$).

Table 3: Pearson Correlation between Pre-service Mathematics Teachers MCK and MPCK Test Scores

		MCK	MPCK
MCK	Pearson Correlation	1	.640**
	Sig. (2-tailed)		.000
	Sum of Squares and Cross-products	43659.314	30762.605
	Covariance	513.639	361.913
	N	86	86
MPC K	Pearson Correlation	.640**	1
	Sig. (2-tailed)	.000	
	Sum of Squares and Cross-products	30762.605	52983.535
	Covariance	361.913	623.336
	N	86	86

** . Correlation is significant at the 0.01 level (2-tailed).

Note. Mean scores were summed to determine overall MCK and MPCK levels

Pearson’s correlation analyses were used to determine if relationships existed between pre-service teachers’ overall mathematics content knowledge and mathematical pedagogical content knowledge levels for six junior secondary school mathematics curriculums. A positive substantial association ($r = .67$) existed between overall mathematics content knowledge and mathematical pedagogical content knowledge levels for the six junior secondary school mathematics curriculums.

5. Discussion of Findings

There is a growing recognition that more research is necessary to explore pre-service teachers’ mathematics content knowledge and mathematical pedagogical content knowledge and

to identify topics in which pre-service teachers struggle with connecting content with pedagogy. The researchers recognize that different mathematical concepts will be difficult for different pre-service teachers depending on their mathematical knowledge for teaching such concepts. As such, the researchers selected some difficult JSS mathematics contents and conducted a paper and pencil test.

Eight-six pre-service teachers participated and the result from the test on JSS Mathematics Contents found that pre-service teachers displayed the highest scores for number and operations knowledge, followed by probability knowledge, trigonometric knowledge and statistics knowledge, lowest performing content knowledge in geometry and measurement, and algebra and functions. This study supports the importance of evaluating pre-service teachers' mathematical knowledge for teaching (Ball, Thames, & Phelps, 2008). Because improving the mathematical knowledge of teachers is key to improving student's mathematical knowledge (Hill, Rowan, & Ball, 2005). The Lagos State Junior School Mathematics Examination assessment is used to measure a student's attainment of the mathematics academic standards and it also determines the admission of such student into Lagos State Senior Secondary school. The junior secondary school mathematics curriculum, cover number and operations, geometry and measurement, algebra and functions, everyday statistics, probability and trigonometry. College of education pre-service mathematics teachers are expected to attain sufficient mathematics content knowledge and mathematical pedagogical content knowledge in these six areas. Bivariate analyses of the six curriculum areas indicated a substantial positive relationship between pre-service teachers' mathematics content knowledge and mathematical pedagogical content knowledge. As pre-service teachers' mathematics content knowledge increased, so did their mathematical pedagogical content knowledge and vice versa, supporting Schneider and Gowan (2013) teachers' skills research. However, for four of the six comprehensive junior secondary school mathematics curriculum areas, pre-service teachers demonstrated only sufficient and adequate mathematics content knowledge in numeration and operations, trigonometry, statistics and probability but having low mathematics content knowledge in geometry and measurement and algebra and functions areas.

Although we expected participants' mathematics content knowledge and mathematical pedagogical content knowledge in these six areas to be highly associated, we also expected that pre-service teachers still in college would have *high* mathematics content knowledge and mathematical pedagogical content knowledge in these six areas of the state-mandated objectives. After all, they are expected to meet the state standards in their first teaching job. Thus, there is much concern about the participants' preparatory programs because of their "sufficient" to "low" mathematics content knowledge and mathematical pedagogical content knowledge for "junior secondary school mathematics curriculum" areas. According to Shulman (1987), learning to teach is complex because teachers need to know not only the subject area in depth, but how to teach the content and explain it in different ways so that diverse students can understand and demonstrate mastery. The findings indicate that pre-service teachers, in this study, needed more preparation in geometry and measurement and algebra and functions areas essential to every junior secondary school mathematics education classroom. To increase their mathematics content knowledge and mathematical pedagogical content knowledge in these six areas emphasis should be lay more on junior secondary school mathematics curriculum of the pre-service teachers' junior secondary school content coursework and mastery of the state mandated objectives to increase their mathematics content knowledge and mathematical pedagogical content knowledge levels.

Pre-service teachers had very adequate mathematics content knowledge and mathematical pedagogical content knowledge levels for junior secondary school mathematic curriculum objectives for which they had high perceived knowledge (that is, numerical content

knowledge, numerical pedagogical content knowledge, probability content knowledge, probability pedagogical content knowledge, trigonometric content knowledge, trigonometric pedagogical content knowledge, statistical content knowledge, statistical pedagogical content knowledge and geometrical pedagogical content knowledge).

Algebra is one of the mathematics concepts that both students and teachers perceived to be difficult to learn and teach. It is important to note that students' scores in algebra might not improve without the involvement of the classroom teacher who constitutes the most important agent in the teaching and learning of the subjects (Oni, 2014). Teachers' mathematics content knowledge and mathematical pedagogical content knowledge are considered important domains of mathematics knowledge for teaching. There is no doubt that there is baseline mathematics knowledge for teaching that teachers should possess in order to successfully apply mathematics content knowledge, curricular knowledge, knowledge of students, and knowledge of enacting teaching. That is, important foundational subject-matter knowledge and pedagogical content knowledge are necessary for teachers' of mathematics to be effective in the classroom. Students who want to become teachers of mathematics need to be exposed to mathematics at junior and senior secondary schools that has sufficient rigour to support such foundations. At college of education level, mathematics lecturers need to be given the scope and flexibility to reinforce student-centred strategies and also build these aforementioned domains of knowledge in our pre-service mathematics teachers. A Teacher that lacks knowledge mathematics content knowledge, curricular knowledge, knowledge of students, and knowledge of enacting teaching will equally fail to identify the ideas and errors behind students' answers, and also fail to explain the sources of students' misconceptions (Boz, 2004 and Stephens, 2008).

6. Conclusion and Recommendations

For a pre-service teacher to help in enhancing students' mathematics knowledge such pre-service teacher must also have been exposed to mathematics content knowledge and mathematical pedagogical content knowledge.

In order for the pre-service teachers to improve in their mathematical knowledge for teaching, additional research in the concepts of pre-service teacher algebraic content knowledge, geometric content knowledge and algebraic pedagogical content knowledge is needed to identify causal factors affecting the less-than-desirable algebraic content knowledge, geometric content knowledge and algebraic pedagogical content knowledge levels for the junior secondary school mathematics curriculum objectives. Specific emphasis is needed in studying the algebraic word problem area. Precisely, why were pre-service mathematics teachers' algebraic content knowledge, geometric content knowledge and algebraic pedagogical content knowledge levels low for this skill area? Did they truly lack adequate coursework experience in their junior secondary school mathematics contents teacher preparation programs? The researchers recommend a need for an intervention that would be channelled towards improving pre-service teachers' algebraic content knowledge, geometric content knowledge and algebraic pedagogical content knowledge repeating. Future studies employing true mixed methods of data analysis should be conducted to determine the effects of instructional strategies on pre-service teachers' mathematical knowledge for teaching. This line of inquiry provides statistical evaluation of pre-service teachers' preparedness in meeting the state-mandated junior secondary school mathematics curriculum objectives. Such new information could be used in crafting guidelines to implement programmatic changes to pre-service mathematics teacher education programs, allowing such programs to better address teachers' mathematical knowledge for teaching.

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