The effect of Ghanaian pre-service teachers' content knowledge on their mathematical knowledge for teaching basic school mathematics

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Abstract

This study measured pre-service teachers' mathematical knowledge for teaching (MKT) basic school mathematics and found the relationship between the content knowledge and their Mathematical knowledge for teaching. MKT multiple-choice test was administered to 100 pre-service teachers from two colleges to assess their mathematical knowledge for teaching basic school mathematics in three content domains – fractions, number operations and number patterns. The results of the tests revealed that the general performance of the pre-service teachers on the MKT test was low. The responses were analysed using SPSS. The mean scores in the three content domains were – fractions (44.0%), number operations (40.4%) and number patterns (50.2%). The study revealed a moderate relationship (ρ=0.388; $p<0.05$) between the content knowledge and MKT of pre-service teachers. It was observed that the poor performance was due to the inadequate opportunities pre-service teachers have to practice what they learn in their pedagogy courses in college. Since pre-service teachers MKT is related to their content knowledge more has to be done for the pre-service teachers to see the inter relatedness of the two. It is recommended that the mathematics pedagogy courses should be made more practical, that is, pre-service teachers given ample opportunity to practice what they are going to teach at the basic schools.

Keywords content knowledge, mathematical knowledge for teaching, pre-service mathematics teachers, teaching basic mathematics

Introduction

The effective teaching of mathematics in general has been a general concern to all stake holders in education especially, mathematics educators. The low standard of mathematics proficiency among pupils and students alike has persisted for decades and test information has consistently indicated problems in the way students learn. Studies by Eshun (1990, 1999) showed that the achievement of senior secondary school students in Ghana in mathematics is low. Criterion Reference Tests (CRT) developed and administered by the Primary Education Programme (PREP) of Ministry of Education, with the support of USAID, for primary six pupils from 1992 to 1996 indicated that less than 10% of the pupils reached mastery and that scores rose steadily beginning from the base year of 1992 (CRDD, 2001). Ghanaian students who participated in the 2003 Trends in International Mathematics and Science Study (TIMSS) performed poorly such that Ghana placed 45th position on the overall mathematics achievement results table (Anamuah-Mensah, Mereku and Asabere-

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Ameyaw, 2004). In TIMSS 2007 Ghana's JHS students scores were lower than those obtained by all participating African countries although; there was an improvement in performance over that of 2003.Ghana's scores were among the lowest, and were statistically significantly lower than the TIMSS scale score average of 500 (Anamuah-Mensah, Mereku and Ghartey-Ampiah, 2008).

At the primary level, the National Education Assessment (NEA) results indicate that the mean scores percent in mathematics for P3 and P6 respectively were 36.6% and 34.4% which revealed poor performance in mathematics (Adu, Acquaye, Buckle & Quansah, 2005). In 2007, the NEA results indicated that the performance of pupils was weak in both English and Mathematics in the two class levels. The mean scores in Mathematics for P3 and P6 respectively were 35.0% and 35.7% (Adu, Acquaye, Buckle & Quansah, 2007).

In an investigation into factors that influence Teachers' content coverage in primary mathematics, Mereku (2004) debunked the educational administrators claims that the poor performance of pupils in the subject was due mainly to lack of confidence and competence on the part of teachers to teach the content of the materials and to use the prescribed methods to facilitate the learning of mathematics in primary schools. However, a decade ago, Dotse (1999) argued that teachers should be blamed for the poor performance of students. Asiedu–Addo and Yidana, 2000) indicated that the low performance in mathematics at the pre-tertiary level of the Education system could be attributed to the low content base of teachers of mathematics. In this study however, the problem of poor performance in mathematics was traced to pre-service teachers' lack of "Mathematical Knowledge for Teaching" (MKT). The study embraces the MKT research whose proponents have conceived that teachers' opportunities to learn must equip them with the mathematical knowledge and skill needed which will enable them to teach mathematics effectively (Ball, 2003). This study therefore draws largely from the MKT work of a team of researchers from the University of Michigan (Ball, Hill and Bass, 2004).

Policy documents indicate that the main objectives of teacher training programmes are to raise the academic level of student teachers, to increase exposure to classroom experience, and, through specific education courses, make them aware of teaching strategies based on pedagogic principles (Akyeampong, Ampiah, Fletcher, Kutor & Sokpe, 2000). Thus, the thrust of pre-service Teacher Education (TE) programme in Ghana appears to be to develop a teacher knowledgeable in the subject areas, and equipped with some fundamental skills of teaching. In effect, it aims at producing a teacher who possesses a critical mass of pedagogical content skills and knowledge which are considered essential to the promotion of children's learning in classrooms.

Ghana has thirty eight (38) Colleges of Education (CE). Individuals who are enrolled into the colleges are known as Pre-service teachers. Pre-service teachers are selected into the CE by virtue of their performance in the West Africa Senior Secondary Certificate Examination (WASSCE) and a selection criteria set by the Teacher Education Division (TED) of GES. The CE operates the semester system. Currently

each pre-service teacher goes through four semesters in college, and one academic year of internship in a Basic School. Pre-service teachers are taken through well planned series of courses to equip them to teach all subjects in the basic school curriculum. The mathematics courses offered at the CE comprises of Content and Methodology. The method courses are offered in the second year of the programme by which time the trainees had already been taken through the basic mathematics content course. It is worth noting that the DBE programme places a great deal of emphasis on content to ensure a sound mathematical knowledge.

Teacher Knowledge and Theoretical perspectives on MKT

A number of studies have attempted to define the nature and the components of teacher knowledge that is necessary for mathematics teaching. Shulman's work initiated the characterization of teacher knowledge (Shulman, 1986; 1987). He distinguishes three categories that describe teacher content knowledge, the subject matter content knowledge – which is the comprehension of the subject appropriate to a content specialist in the domain, the pedagogical content knowledge – to refer to the special nature of the subject-matter knowledge required for teaching that is, the understanding of how particular topics, principles, strategies and the like in specific subject areas are comprehended or typically misconstrued; and the curricular knowledge to mean the familiarity with the ways in which knowledge is organized and packaged for instruction in texts, programs, media, workbooks, other forms of practice, and the like (Shulman, 1986a). From the wide-ranging issue of subject-matter content knowledge, Shulman chose to focus on the claim that "the teacher need not only understand that something is so, the teacher must show why it is so" (Shulman, 1986b).

Although these categories are not specific to mathematics teaching, many researchers in mathematics education have used these as a framework of their work (Potari, Zachariades, and Pitta-Pantazi, 2008). In particular, the notion of pedagogical content knowledge which identifies the special kind of teacher knowledge that links content and pedagogy is used as the basis to define the specialized mathematical knowledge that the teacher needs.

This study however is based on the assumption that effective teaching requires teachers to attend to and endeavour to understand the mathematical ideas and reasoning of their students (Sowder, in press). In agreement with Shulman (1986) who identified content knowledge, pedagogical content knowledge and curricular content knowledge; my perspective recognises that to teach a school subject like mathematics effectively necessitates knowledge of mathematics that "goes beyond the knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" (Shulman, 1986). However the researcher's view of mathematical knowledge for teaching transcends an epistemological stance that it entails "ways of representing and formulating the subject that make it comprehensible to others" (Shulman, 1986).

For more than a decade, Ball and her colleagues have been developing on a programme of research using Shulman's (1986) view as a reference point. In 1997,

they began a close examination of the actual work of teaching elementary school mathematics. They noted all the challenges in the work of teaching that draw on mathematical resources, and then analyzed the nature of such mathematical knowledge and skills and how they are held and used in the work of teaching. From this they derived a practiced-based portrait of what they call "Mathematical Knowledge for Teaching" (MKT) - a kind of professional knowledge of mathematics different from that demanded by other mathematically intensive occupations, such as engineering, physics, accounting, or carpentry. In this framework the researcher believes in the perspectives of MKT and the domains of MKT tied to the work of teaching.

Ball and Bass (2000) used the term MKT to capture the complex relationship between mathematics content knowledge and teaching. Brink (2007) contends MKT is the domain of knowledge that a teacher uses in the act of teaching. Sleep and Ball (2007) defined Mathematical Knowledge as skill, habits of mind that are entailed by the work of teaching. Wagner and Speer, (2008) added that MKT is a resource that teachers draw upon to accomplish a variety of teaching-related tasks such as following students' mathematical thinking, evaluating the validity of student-generated strategies, and making sense of a range of student - generated solution path MKT simply means the mathematical knowledge used to carry out the work of teaching.

Ball, Bass, Sleep and Thames (2008) in a draft on 'A theory of Mathematical Knowledge for Teaching' cited the following as an example of MKT by asking what kinds of common and specialized mathematical knowledge and skills that are needed for the distinctive work of teaching? To illustrate, they examine a simple subtraction computation:

$$\begin{array}{r} 307 \\ -\ 168 \\ \hline \end{array}$$

Most remember an algorithm that produces the answer, 139:

$$\begin{array}{r} {}^{2}\not{3}\,{}^{1}\not{0}\,{}^{9}\not{7} \\ -\ 1\,6\,8 \\ \hline 1\,3\,9 \end{array}$$

It is necessary to be able to perform this calculation in teaching. This is what they termed common content knowledge (CCK), shared by most educated adults. But being able to carry out the procedure is not sufficient for teaching it. For instance, this algorithm is one with which many primary school children struggle, often making errors. One common error is:

$$\begin{array}{r} 307 \\ -\ 168 \\ \hline 261 \end{array}$$

They explained that a teacher needs to be able to do more than just immediately spot that 261 is incorrect. Skilled teaching requires being equipped to help a student learn to get it right. A teacher with specialized content knowledge (SCK) can analyze the site and source of errors. Here, for example, a student has, in each column, calculated the difference between the two numbers, or subtracted the smaller digit from the larger one. Teachers need to be able to perform such error analysis, efficiently and fluently. Such analysis often requires specialized knowledge of mathematics, detailed in ways that most adults do not have at their fingertips.

Apart from error analysis, teaching also involves explaining procedures such as this one. One could give a set of procedural directions specific to this calculation, but this would not generalize to, for instance, 314–161, where one only "crosses out" and "puts" once, not twice. It also does nothing to show why the procedure works. What is an effective way to represent the meaning of the subtraction algorithm – not just confirm the answer, but show what the steps of the procedure mean, and why they make sense?

They made clear the fact that, teaching also involves considering what numbers is strategic to use in an example. 307 and 168 may not be ideal choices to make visible the conceptual structure of the algorithm. They further raised these questions; what is revealed by numerical examples that require two regroupings instead of one, or by a sequence of examples from ones requiring no regrouping to ones that require several? What about the role of zeros at different points in the procedure? Questions such as these require a kind of mathematical insight and problem solving unique to teaching.

Ball, et. al., (2008) continued that teachers should not lost sight of the fact that, the illustration involves knowing nothing about students and nothing yet implies a particular course of pedagogical action. Each step in the example so far has involved a deeper and more explicit knowledge of subtraction than that entailed by simply performing the calculation. Each step points to some element of knowing mathematics in ways central to teaching it. The example therefore helps to clarify that knowing mathematics for teaching demands a kind of depth and detail not needed for carrying out the algorithm reliably. Second, the example also shows that there are predictable and persistent tasks that teachers face that are deeply entwined with mathematics and mathematical reasoning, figuring out where a student has gone wrong (error analysis), explaining the basis for an algorithm and showing why it works (principled knowledge of algorithms, and reasoning), and selecting strategic examples (mathematical problem solving). It is important to note that each of these common tasks of teaching is as much a mathematical undertaking as it is a pedagogical one. The argument is not that teaching requires only content knowledge rather; it is that teaching demands in addition to many other resources - a specialized kind of content knowledge too often overlooked.

Content Knowledge of pre-service teachers

In contrast to MKT, Content Knowledge as explained by Shulman, (1986a) is subject matter knowledge which is the comprehension of the subject appropriate to a content

specialist in the domain. Content Knowledge has a crucial effect on a teacher's response to various class situations, such as when a JHS 1 student claims that the minuend is always greater than the subtrahend. It is therefore important that teachers know the topics and procedures that they teach, primes, equivalent fractions, functions, factoring and so on. It is for this reason that Teacher Education and policy makers of Teacher Education have designed the DBE mathematics course to include Content Knowledge. Phillip, Armstrong and Berzuk (1993) suggested that in order to build pre-service teachers' sense of content knowledge for teaching mathematics, Colleges of education need to help pre-service teachers spend as much time as possible with the content they will be teaching while exploring the ways in which primary students develop conceptions and misconceptions about this content. Ball et al. (2005) stressed the importance of allowing pre-service teachers opportunities to review basic mathematical concepts, discuss other ways to solve problems, and explore using various representations in order to support their content knowledge for teaching mathematics.

Upon examining effective ways to increase content knowledge for teaching elementary school mathematics, Hill and Ball (2004) found that out of 15 professional development institutes in California, in-service teachers demonstrated the greatest growth through professional development that focused on mathematical content and problems they would face as teachers. They again suggested focusing on mathematical content demonstrate the greatest growth in content knowledge for teaching mathematics.

A critical examination of the way teachers are prepared in Ghana seem to support the view that teachers are to be blamed for the poor performance in the subject. A study conducted by Obeng, Opare and Dzinyela (2003) indicated that trainees were not strong enough in subject matter content. Akyeampong (1999) pointed out earlier that graduate of teacher training colleges are ill-prepared in facilitating learning in basic schools. This, Quagrain (1999) also made a similar observation that most beginning teachers are seen as woefully unprepared for the complex and demanding tasks of the classroom, and Pre-service Teacher education has been regarded as pathetically weak and beginning teachers are found wanting and desperate in their initial experience. This observation has not changed because pre-service teachers are still exhibiting weak performances in their 'End of Semester Examination' (Institute of Education, 2006, 2007). These give the impression that there has been little improvement in mathematics education. This is to be expected because most teachers like most other adults in this country are graduates of the very system we seek to improve. Their own opportunities to learn mathematics have been uneven, and often inadequate, just like those of their non-teaching peers.

The question now is what can be done to raise the state of mathematics in our country? If the pre-service teachers who are to impart the knowledge are not up to the task, then what will become the standard of mathematics education in our country? Perhaps one way of resolving this non performance in mathematics education is by

ensuring that basic teachers' Mathematical knowledge for Teaching (MKT) is firmly grounded. This is because studies have shown that teachers' mathematical knowledge helps support increased student achievement, because the better that teachers are at understanding mathematics in ways that give them flexibility and insight, the more their students learn (Ball, Hill and Bass, 2005).

Having been established that one of the most important factors which influence students' performance are the mathematics teachers and the mathematics lessons they receive in school; it is significant that a comprehensive look is made into the Mathematical Knowledge for Teaching (MKT) of pre-service teachers in ascertaining whether the mathematics course of the DBE progamme help develop their MKT. In a bid to looking into their MKT level, the study sought to find out how the pre-service teachers fared in the three content domains of the MKT test tested?

Methodology

Design and sample

The design used for this study was survey in which multiple choice test questions were administered to pre service teachers to assess their mathematical knowledge for teaching basic school mathematics. The study targeted all pre-service teachers in the Colleges of Education (CE) in Ghana but only two colleges (located at Mampong in the Ashanti Region of Ghana) were purposively selected. A total of 100 pre-service teachers were randomly selected and used for the study. The selection of these colleges was based largely on proximity, familiarity and accessibility to the researcher. Again, the two schools happened to be all single sex schools which represented both sexes of the larger population and for the fact that all colleges have similar characteristics; they were highly representatives of the population.

Instrumentation

The instrument used in the data collection is the MKT test and the results (CK) of the pre-service teachers' first year content examination results. The MKT test items used in assessing the pre-service teachers' knowledge was adapted from the MKT measures developed by a research team in Michigan University (Ball et al., 2005). These items require that teachers respond to mathematical issues that arise in teaching, like assessing pupils' mathematical work, representing numbers and operations in the context of instructions, or explaining common mathematical rules or procedures. The questions also involved mathematical knowledge used to carry out the work of teaching mathematics like explaining terms and concepts to students, interpreting students' statements and solution, using representation accurately in the classroom. The MKT test consisted of 20 multiple choice items with some isolated items having three or more sub-items which made a total of 37 items. The MKT multi-choice items were scored using a rating of 0 and 1 for wrong and right responses respectively. The results were then converted to 100%. The MKT measures have a wide range of questions on various topics but in this particular study only three content domains identified in the DBE mathematics course was considered. This is to

say that not all the topics in the DBE mathematics course were covered in this study therefore caution should be exercised in generalizing the results for the entire content of the DBE mathematics course.

Records on respondents' performance in their first year mathematics content examination were collected from the colleges. The DBE examination is moderated by the Institute of Education, UCC. The examination is taken at the end of each semester and is scored 70% of the total mark (100%) whiles 30% of the mark is internally moderated at the various colleges through continuous assessment.

Reliability and Validity

To ensure the validity of the MKT test colleague mathematics tutors from the CEs were made to confirm whether the content of the MKT are within the course outline of the DBE programme. A pilot test of the instruments was carried out with 30 pre-service teachers of a college in the Central Region. The emphasis of the pilot study was to make sure that the items were clear and void of ambiguities to the pre-service teachers. A discussion held after the pilot study with respondents indicated that the MKT items do not deviate from what they learnt at college and are similar to the experiences they encounter on the field. It is worth noting that the pre-service teachers used for the pilot study did not form part of the sample for the study.

However the reliability of the MKT measures was not computed in this study since earlier study has tested and established the test to be reliable and valid (Hill, Shilling and Ball, 2004). Previous work of Hill, Shilling and Ball (2004) had shown that a MKT measure composed of multiple-choice items representing teaching-specific mathematical skills can both reliably discriminate among teachers and meet basic validity requirements for measuring teachers' mathematical knowledge for teaching.

The researcher visited the sampled colleges in the latter part of the first semester of the CE to discuss the study and sought permission from the Heads of Department, where she obtained information from the teaching practice coordinators on the various villages pre-service teachers were stationed. This enabled her to select nearby villages which host pre-service teachers from the two colleges.

The test was self-administered to pre-service teachers in their various schools at the villages in the fourth week into the second term of the Basic School academic calendar. Pre service teachers had two hours to respond to both tests with the researcher playing the supervisory role to ensure that they did independent work.

Results and data analysis

The data collected was analysed quantitatively. The Statistical Package for Social Sciences (SPSS) was applied for the analysis of data. The data of the MKT test was coded and keyed into the SPSS for the statistical analysis. The preliminary analyses were done using descriptive statistics as well as absolute figures and percentages to describe the general characteristics and properties of the variables being examined.

Overall Performance on the MKT test

The general performance of pre-service teachers on the MKT test was low. Most of them scored less than half the total mark. The highest score on the test was 73% and the lowest was 19%. Majority (75%) of pre-service teachers had between 32%-51%. Only eight (8%) pre-service teachers had marks ranging from 60%-73%. In all 32% of them had above 50% which is the pass mark in the DBE programme whilst 68% had marks below 50% (Appendix 2).

Table 1 Overall MKT score

	N	Minimum	Maximum	Mean	Std. Deviation
MKT Score	100	19	73	45.5	9.6

Table 1 shows the minimum and maximum marks made by the pre-service teachers in the MKT test. The mean mark made was 45.5 with a standard deviation of 9.6. Table 2 shows the range of scores as indicated by the 5th and 90th percentiles. The 5th percentile score indicates the highest score obtained by the bottom 5% (27) whilst the 90% shows the top 10% least score of 58. The range is from 27 to 58 (i.e. a difference of 31 scores) which shows how close pre-service teachers scores were in their MKT abilities.

Table 1 Percentiles of MKT Score

Percentile	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile
Percent Score	27	32	41	46	51	58

Figure 1 Pre-service teachers' performance on the MKT test

The pre-service teachers' performances were further examined under three content domains - fractions, number and number operations, and number patterns.

Discussion

The results of the content domains have been graphed in Figure 2. The pre-service teachers' performance in Number patterns and rules were better than Fractions and Number Operations (see Figure 2). The least scored was Number Operations which the researcher feels should have been best scored by pre-service teachers. This is because the types of questions asked in this domain were similar to those that the pre-service teachers encounter in the classrooms daily.

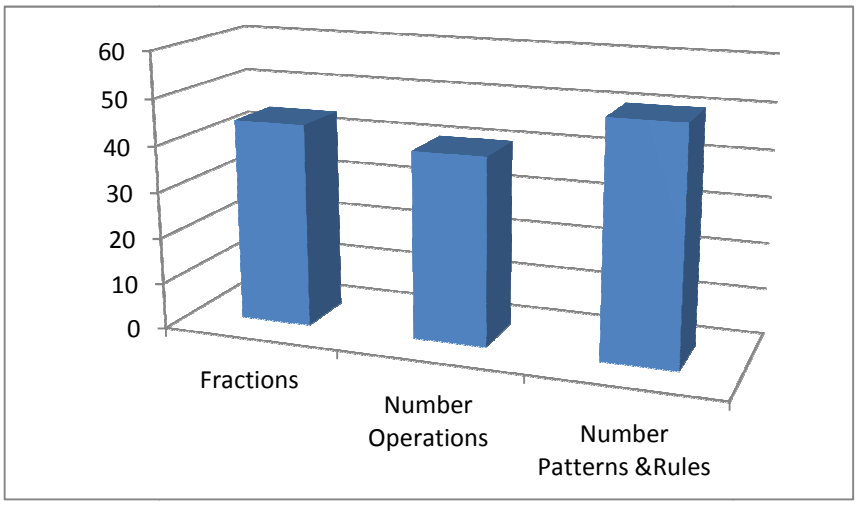

Figure 2 Mean Scores on the Content domains of the MKT test

Under fractions, the pre-service teachers were found battling with fractions representations in other forms which is also very important in teaching mathematics. Exposing students or pupils to variety of models help make meaning of concepts clearer. Again, it was observed from the results that the pre-service teachers had difficulties in the identification of the values of the blocks in the teaching of decimals. Also they could not apply the knowledge they had in divisibility to show whether 371 is a prime number. This indicates how pre-service teachers learn, they learn by rote without making meaning of what they learn. These findings were found to be consistent with observations made by Ball, Hill and Bass, (2005) that the mathematical knowledge of many teachers is dismayingly thin.

Pre-service teachers' performance in final DBE mathematics content examination and entry qualification in mathematics

Data was collected from the two colleges on the results of the pre-service teachers' content knowledge. The DBE examination as indicated earlier is moderated by the Institute of Education, UCC. The examination is taken at the end of each semester and is scored 70% of the total mark (100%) whiles 30% of the mark is internally moderated at the various colleges through continuous assessment.

Table 5 shows the percentages of students performing above or below particular points (from the 10th to 90th percentiles) on the DBE examination. The 10th percentile indicates the lowest limit where the bottom ten percent of pre-service teachers scored below 50% in the Content Knowledge Examination while 90 percent scored higher than 50. The 90th percentile is the highest limit above which only the top ten percent of pre-service teachers had a score of 77%. Fifty percent of pre-service teachers did not score beyond 63%. It is observed that majority of pre-service teachers fell within the median score (50th percentile).

Table 5 Percentile of Content Knowledge Scores

10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile
50	55	63	69	77

It is important to point out that the performance in the content knowledge examination is somehow better than the performance in the MKT test they took. More than half (61%) of the pre-service teachers entered the colleges with grades D and E. 26 of them entered with a grade B. This might explain the average performance being exhibited in their content knowledge test. On the highest grade scored since they enrolled in the DBE mathematics course 15 had had A; 15, B+; B, 28. 34 of them had had C and C+ with 7 having D. This reveals an improvement in performance in mathematics. The results therefore confirm the response the pre-service teachers gave that the DBE programme has added more value to their performance in mathematics. The scores of the content knowledge test and the MKT test as presented in Tables 5 and 1 respectively reveal a difference in the scoring rate. To verify whether or not a relationship existed between content knowledge and MKT the data was subjected to further analysis to test the hypothesis that "there is no significant relationship between content knowledge and MKT."

The correlation coefficient was calculated with the aid of the SPSS Computer software and a Spearman rho's correlation coefficient of .388 was observed to be significant at 0.01, thereby rejecting the null hypothesis that there is no significant relationship between content knowledge and MKT. The alternate hypothesis that there is a significant relationship between CK and MKT was accepted. Therefore it can be concluded that there is a positive moderate correlation between Content Knowledge and MKT.

It can be explained from the trend of results that content knowledge plays a positive role in the development of MKT. For instance, pre-service teachers who had higher marks were observed to be obtaining relatively better marks in the MKT test. This is clearly depicted in the scatter plot in Figure 3.

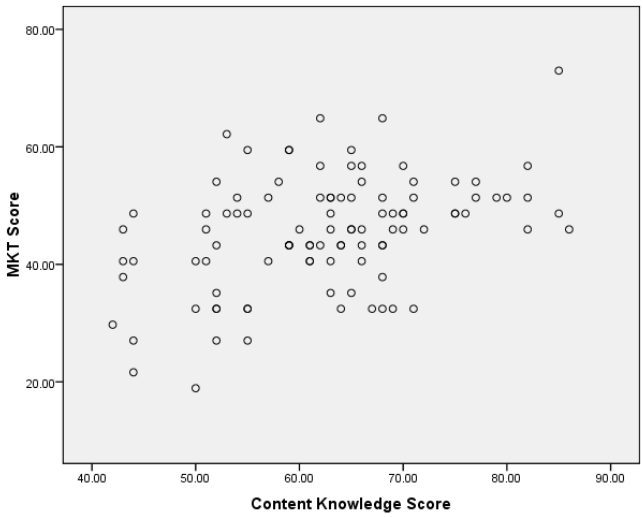

Figure 3 Scatter plot of pre-service teachers' content knowledge and MKT

The scatter plot in Figure 3 illustrates a positive correlation in that the data points start from lower left to the upper right of the graph. This brings to the fore the power of the idea lunched by Shulman and his colleagues (1986a), that teaching demands content knowledge and is obvious which explains why Teacher Education division and stake holders in teacher education are eager to set requirements based on the common sense notion.

Conclusion and recommendations

The study revealed a relationship between the content knowledge and MKT of pre-service teachers. It was observed that pre-service teachers who had higher marks in the CK examination obtained relatively better marks in the MKT test. It can be explained from the trend of results that content knowledge plays a positive role in the development of MKT. This therefore brings to fore the idea launched by Shulman and colleagues (1986a) that teaching demands content knowledge and is obvious. This explains why the Teacher Education Division and stakeholders in teacher education in Ghana have set requirements based on the common sense notion. The results of this study revealed that having a deep understanding of content knowledge is necessary but not sufficient to teach mathematics and it is not possible to teach mathematics effectively without having MKT as well. Ball, Bass, Sleep and Thames (2008) intimated that teaching requires not only content knowledge but also MKT, a specialized kind of content knowledge too often overlooked.

As indicated in this study, the pre-service teachers' knowledge in MKT of the three content domains is very thin. This is because the pre-service teachers' are not given more opportunities to practise what they learn as prospective teachers. On the whole these findings, as already indicated, are not surprising, given that the pre-service teachers have learned mathematics within the same system that so many are seeking to improve. The fact that their understanding is more rule-bound than conceptual, and

more fragmented than connected, reflects the nature of the teaching and curriculum they had, like other Ghanaian adults, experienced in basic and secondary schools. However, if pre-service teachers are to be equipped with knowledge and skills to improve mathematics teaching and learning, they will have opportunities to revise and develop their own MKT.

It is recommended that remedial lessons be organised for pre-service teachers' to step up their content knowledge acquisition in order to improve their MKT. They should be given more opportunities to practise what they learn as prospective teachers. The focus should be on pre-service teachers mathematical knowledge required for teaching. In addition, pre-service teachers should be taught in ways that would expose them to different representation of ideas in variety of models. Ball et al (2005) stressed the importance of allowing pre-service teachers opportunities to review basic mathematical concepts, discuss other ways to solve problems, and exploring using various representations in order to support their content knowledge for teaching mathematics.

Finally, it is also recommended that other studies should be done in the other content domains of basic mathematics like algebra, geometry and measurement. Another important issue that needs to be further investigated in basic mathematics teacher education is the ways that the specialised mathematics knowledge for teaching can be developed.

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