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Assessing Factors Influencing Pre-Service Teachers' Mathematical Knowledge for Teaching (MKT) Mathematics in Ghanaian Basic Schools

Article by Millicent Narh-Kert[1], Ernest Ampadu[2]
[1]Accra College of Education, Ghana
E-mail: millicentnarh@yahoo.com[1], eampadu@ug.edu.gh[2]

Abstract

Introduction: *Knowledge about teaching mathematics remains a contentious issue in the preparation of pre-service teachers. This study assessed factors influencing pre-service teachers' mathematical knowledge for teaching (MKT) mathematics in Ghanaian basic schools.*

Methods: *The cross-sectional survey design was adopted for this study. A total of 998 pre-service teachers from ten (10) public colleges of education were sampled via multi-stage sampling technique for the study. Structured questionnaire and unstructured observation schedule were used to conduct the survey. Secondary data was also collected in the form of mathematics test results. The Statistical Package for Social Sciences version 22 was used to analyse the data using descriptive statistics (frequency count, percentage) and inferential statistics (Pearson's correlation, multiple regression, exploratory factor analysis).*

Results: *The study revealed that many pre-service teachers in Ghanaian public colleges of education had weak mathematics content knowledge. The following factors influenced MKT of the pre-service teachers: gender, ways of imparting mathematics knowledge, perception about mathematics as a subject, perception about mathematics teaching and learning and attitudes towards mathematics ($p < .05$).*

Conclusions: *This study exploring the factors that influence pre-service teachers' MKT suggests that, to be able to build effective mathematics teacher base in any basic school, there must be effective training on factors like gender, perception, and attitude. There is therefore the need for the National Council for Tertiary Education to emphasis on factors that influence MKT besides the content of the college of education mathematics curriculum.*

Keywords: *Colleges of education, mathematical knowledge for teaching, pre-service teachers.*

Introduction

Individuals who enroll into colleges of education (CoE) in Ghana are known as pre-service teachers or teacher trainees. Pre-service teachers are selected into the CoE by virtue of their performance in the West Africa Senior Secondary Certificate Examination (WASSCE). Currently, each pre-service teacher goes through four semesters in college, and one academic year of internship in a basic school. The mathematics courses offered at the CoE comprises content and methodology courses. 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 believed that the pre-service training mathematics curriculum will equip pre-service teachers with the basic mathematical knowledge needed for teaching at the primary and junior high school (JHS) during their internship and upon completion of their training.

The thinking and practices of preservice teachers are shaped by background attributes such as entry behavior (e.g., entry level mathematics content knowledge), professional and life experience, the nature and extent of teacher preparation and continued professional learning. For this reason, colleges of education (CoE) in Ghana are strategically positioned to train teachers to acquire the professional competence with which to impart knowledge to learners in basic and high schools. Accordingly, preservice mathematics teachers' preparation should entail all the necessary conditions needed to equip them with the requisite mathematical knowledge for teaching (MKT). MKT is the domain of knowledge that a teacher uses in the act of teaching [1].

The study of science and mathematics among Ghanaian children has been a subject of concern over the last three decades [2]. A number of indicators have made it clear that children in basic schools and secondary schools are not doing well in science and mathematics. Results of the National Education Assessment (NEA) in mathematics that is administered to a sample of third grade and sixth grade pupils every two years, indicate that over the last six years, less than 20% reached proficiency level in mathematics [3]. Several researchers [4, 5, 6] have found that pre-service teachers do not always possess the conceptual understanding of the mathematics content they will be expected to teach. Evidence of this is highlighted in the 2008 chief examiners report on teaching primary mathematics. Also, pre-service teachers are still exhibiting weak performances in their 'End of Semester Examination' [7] giving the impression that there has been little improvement in mathematics performance over the years. This phenomenon could be partly attributed to inadequate mathematical knowledge for teaching (MKT) by teachers who teach pupils from the lower level through to higher levels. It has been indicated that the low performance in mathematics at the pre-tertiary level of the education system could be attributed to the low content base knowledge of teachers of mathematics [8]. Perhaps one way of resolving this non-performance in mathematics education is by ensuring that basic teachers' MKT is firmly grounded. It is therefore important that a comprehensive look is made into the MKT of pre-service teachers in Ghanaian colleges of education.

There is a phenomenon of poor performance of pupils in mathematics in Ghanaian basic and senior high schools, and this is possibly traced to pre-service teachers' poor mathematical knowledge of teaching [MKT] [9, 10]. This suggests that colleges of education and universities that train teachers in Ghana have not yet been successful in grooming teacher trainees become confident and competent in the teaching of mathematics. A critical examination of the way teachers are prepared in MKT in Ghanaian colleges of education seemed to suggest that they are ill-equipped with MKT. Oftentimes, pre-service mathematics teachers in Ghanaian colleges of education experience the challenge of transitioning their mathematical knowledge of teaching from the college setting to future school (field) settings (David, A. personal communication, 17th April, 2019). It is observed that they experience the difficulty of integrating theory and practice, and/or integrating knowledge gained between classroom and the field [11]. A number of performance indicators revealed downward trends in mathematics performance [7]. At the primary level, for instance, National Education Assessment (NEA) report by the Ministry of Education (MoE) in Ghana indicated that less than 20% reached proficiency level in mathematics at P3 and P6 over the last six years [12]. At the Basic Education Certificate Examination [BECE] (2014, 2015, 2016, 2017), Chief Examiner's report by the West African Examination Council (WAEC) revealed candidates' performance falling below average in mathematics. The poor results in NESAR at P2 indicates undue focus on memorization of facts and rules; J.H.S 2 students performed poorly in international assessment such as TIMSS; WASSCE results for SHS students showed poor performance in integrated science and core mathematics with about 60% obtaining poor grades [12]. Teaching primary and junior high secondary mathematics was not satisfactory; only a limited number of the candidates exhibited good mastery in areas tested [7]. For this reason, this study assessed the mathematical knowledge for teaching (MKT) of pre-service teachers in teaching basic school mathematics, and practical ways to enhance pre-service teachers' MKT for teaching and learning in Ghanaian basic schools. Additionally, it investigated the factors influencing Ghanaian public colleges of education pre-service teachers' mathematical knowledge for teaching basic school mathematics.

The study adopted the Constructivist Theory in mathematics teaching and learning. Constructivism is derived from the works of Jean Piaget [13], Lev Vygotsky [14], John Dewey [15] and many others as cited in Acikalin [16] who studied how learners acquire knowledge. Constructivism is a philosophy of learning founded on the premise that, by reflecting on our experiences, learners construct their understanding of the world they live in. Constructivism represents a change in perspective on what knowledge is and how it is developed [17]. A constructivist approach to mathematics learning involves the child as an active participant in the learning process. The constructivist view of knowledge has been associated to mathematics learning and teaching. From a constructivist perspective, knowledge is not passively received from the world, from others, or from authoritative sources. Rather, all knowledge is created as individuals adapt to and make sense of their experiential worlds [18]. Applying these ideas to mathematical knowledge for teaching (MKT), mathematics is viewed as an ongoing process of human minds, not an aspect of the external world waiting to be discovered [19]. According to Glasersfeld and Steffe (1991), the essence of constructivism can be summarized in the following way: *knowledge cannot simply be transferred ready-made from parent to child or from teacher to student but has to be actively built up by each learner in his own mind* [18]. In the constructivist classroom, a teacher has an important role. Rather than a dispenser of knowledge, the teacher is a guide and facilitator who encourage learners to question, challenge, and formulate their own ideas, opinions and conclusions. Although (social) constructivist perspective on learning has provided mathematics educators with useful ways to understand learning and has given a useful framework for thinking about mathematics learning in classrooms, it does not define any particular model for teaching mathematics [19]. This framework also bears on subject-matter content knowledge by Shuman [20] who viewed mathematics content knowledge as rooted in knowledge and application of procedural facts, algorithms, and methods as well as the understanding of how these are interrelated [21]. Figures 1 and 2 presented the conceptual frameworks for the study.

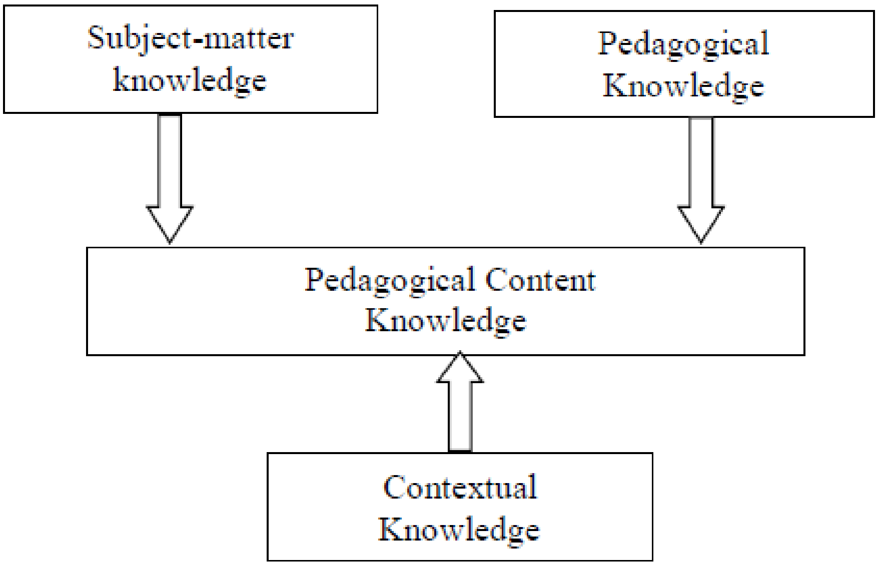

Figure 1. Adapted conceptual framework

Source: Adapted from Gess-Newsome [22].

In Figure 1, the model depicts that teaching mathematics requires subject matter knowledge which is the element of mathematics the teacher is supposed to teach, the pedagogical knowledge which is the knowledge about the child being taught and contextual knowledge which forms the part of content to be taught. The mathematical knowledge (MKT) for teaching that mathematics teachers need to know is substantial. The researcher therefore sort to find ways to improving the teaching and learning of mathematics in the basic school by considering the model that has a direct implication on the use of manipulatives for practicality and the attitudes of the teacher being trained to take up the task of teaching mathematics in the basic school. The National Council of Teachers of Mathematics (NCTM) argue that traditional, procedural-based approaches to mathematics teaching do not prepare students enough for higher level mathematics. To them, success in higher level mathematics is dependent on students' understanding of concepts as well as procedures. In order for students to receive mathematics instruction that attends to concepts as well as procedures, teachers must receive additional training in MKT and support to deliver instruction in a more conceptually-based way [23, 24].

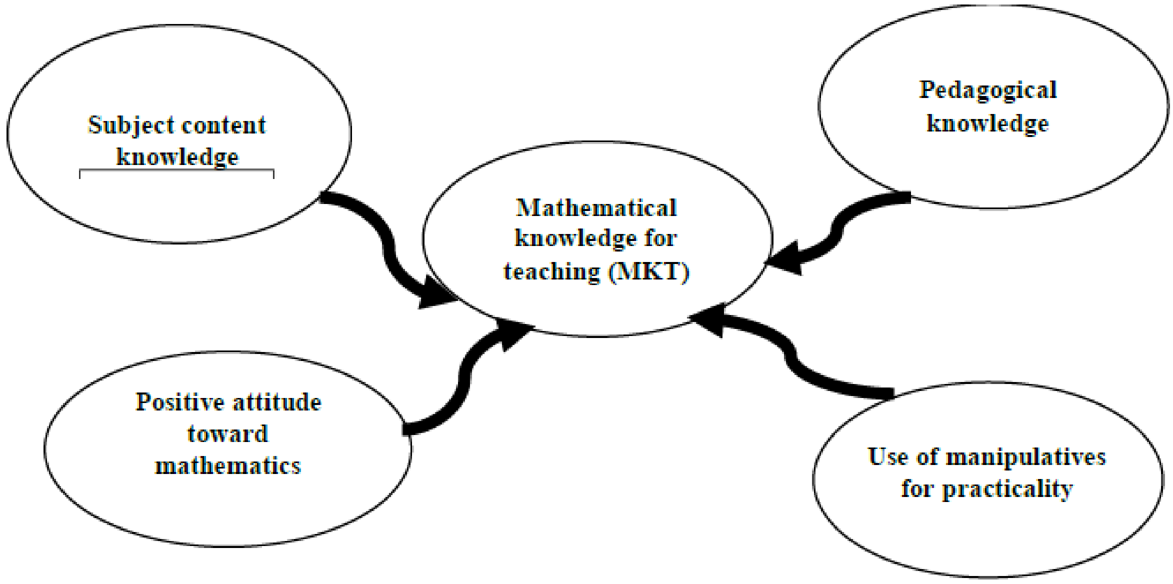

Figure 2. Mathematical knowledge for teaching basic school mathematics

Source: Researcher's construct (2019).

The main difference between the adapted framework (Figure 1) and the researchers' framework (Figure 2) is that, the researcher is considering a model that depicts the knowledge that is needed in teaching mathematics to the basic school child who is mainly at concrete operational stage [25]. This involves subject matter knowledge which is the element of mathematics the teacher is supposed to teach, the pedagogical knowledge which is the knowledge about the child being taught, the use of manipulatives for practicality in teaching, and considering the teachers' attitude towards the subject he or she is supposed to teach. In order to construct mathematical concepts in students' mind, pedagogical knowledge as well as subject content knowledge are needed. The manner in which teachers relate their subject matter (what they know about what they teach) to their pedagogical knowledge (what they know about the children they are teaching) and how instructions are structured with the use of manipulatives in an honest manner coupled with positive attitude to mathematics are seen as integral of mathematical knowledge for teaching (MKT). The pedagogical content knowledge of the adapted model is one aspect of mathematical knowledge needed to teach the basic school child. To teach a basic 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 [20]. So, pre-service teachers require mathematical content knowledge before taking up the job as service teachers. The next section discusses the conceptualization of mathematical knowledge for teaching (MKT) and factors influencing its development.

The way teachers instruct in a particular content is determined partly by their pedagogical content knowledge which '*goes beyond knowledge of the subject matter per se to the dimension of the subject matter knowledge for teaching'* [20] and partly by teachers' mathematics-related beliefs [26, 27]. MKT has been described as the complex relationship between mathematics content knowledge and teaching [28]. It is the domain of knowledge that a teacher uses in the act of teaching. In other words, MKT involves knowing what kinds of common and specialized mathematical content with knowledge of skills needed for the distinctive work in teaching mathematics [1]. Some studies aimed at teachers' mathematical knowledge mainly have focused on two topics: first, the teachers' characteristics, for example, the number of mathematics courses they have completed, and second, the nature of teachers' mathematical knowledge [29].

A study of developing measures of teachers' MKT revealed that teacher's knowledge for teaching basic mathematics is multidimensional and includes knowledge of various mathematical topics (example, number and operations, and algebra) [30]. A research team in Michigan has developed a questionnaire to measure MKT. The purpose of the measures is to research the nature, role and different types of mathematical knowledge for teaching [31]. The MKT measures were originally developed to measure and research the mathematical knowledge for teaching held by US teachers. The fact that the measures relate to the task of teaching, not teaching practice, makes them more universal and more suitable for translation mathematics, and teaching material when attempting to translate and adapt the MKT measures [31, 32, 33]. The investigation of the MKT measures' adaptability can be useful for future studies because it can enable comparison of teachers' knowledge across nations [32]. Even though adjusting and translating the MKT measures involve challenges and cost, it is worthwhile since the MKT measures give an opportunity to measure teachers' knowledge at scale with quality [34]. The MKT measures have been used to measure teachers and prospective teachers' mathematical knowledge for teaching outside the US. They have been adapted and translated for use in Ghana, Indonesia, Ireland, Korea, and Norway [35].

Prospective mathematics' teachers need to understand the content knowledge and fundamental principles that underlie school mathematics. Teacher's knowledge of mathematics is a complicated conceptual structure, including its structure and unifying concepts; knowledge of procedures and strategies; history of mathematics; links with of other subjects and knowledge about mathematics as a whole [36]. In Ghana, teaching in the basic school especially at the lower level requires that teachers must know some amount of mathematics (content knowledge) studied at that level. Teachers' content knowledge is related to the mathematical quality of teachers' instructions and teaching style [37, 38, 39, 40]. Extensive evidence suggests that it is important to develop teachers' mathematical content knowledge and values so that teachers can more effectively support students' mathematical learning [41, 42, 43].

A teacher in mathematics needs a subject matter knowledge that is a knowledge about and of mathematics [20, 36], which includes knowledge of the content of a subject area as well as understanding of the structures of the subject matter [20, 44]. Teachers' knowledge of teaching mathematics is based on their learning experiences in mathematics. This knowledge is developed during the studies of mathematics but most of this knowledge is acquired in teacher education, teacher practice or in place of work [36]. Teachers' knowledge of mathematics is important for utilizing instructional materials in most productive way, assessing students' progress and finding the most effective presentation and sequence of the subject [37, 45]. Therefore, colleges of education in Ghana 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.

Researchers have been influential in the project to better understand teachers' knowledge of mathematics [46]. The choice of ways to measure the mathematical content knowledge of prospective teachers was grounded in the work of Ball and the research team at the University of Michigan [30, 47, 48], and their definition of common content knowledge (knowledge held by people outside the teaching profession) and specialized content knowledge (knowledge used in teaching) [49]. A study found that pre-service teachers in the graduate program had an inadequate, basic mathematics background to prepare K-12 students [50]. More so, few studies on measuring MCK have been done in developing countries. In their systematic review, some researchers found only one study of MCK that included an African country [51, 52].

Materials and methods

This is a quantitative research which adopted the cross-sectional survey design. The rationale for the adoption of a cross-sectional survey design was that it relied on large-scale data from a representative sample of a population with the aim of describing the nature of existing conditions [53]. The target population was three thousand, three hundred and forty (3342) second-year or level 200 pre-service teachers in forty-six (46) public colleges of education in Ghana. Multi-stage sampling was used in sampling nine hundred and ninety-eight (n = 998, 30%) second year pre-service teachers from ten (10) conveniently selected public colleges of education for the study. These colleges categorized into three geographical clusters or belts of Republic of Ghana, namely; the Southern, Central and Northern belts. Purposive sampling was used to pick level 200 students. The second-year group was purposively chosen because, with the curriculum of colleges of education, methodology courses which are actually pedagogical knowledge of the various subject areas are taught in second year besides the content knowledge studied in level 100. Therefore, they were chosen since the researchers' objective was to assess mathematical knowledge for teaching (MKT) which embodies the mathematical content knowledge and pedagogical knowledge of pre-service teachers for teaching basic school mathematics. The third-year students were already in off-campus for teaching practice. A combination of stratified and simple random sampling techniques was used to sample 998 (30%) trainee (pre-service) teachers of the target population. The stratified sampling technique was used to categorise and select the respondents based on gender. The simple random sampling technique using the lottery approach was then used to select 645 (65%) males and 353 (35%) female students from the sampled colleges of education. The choice of 15% of the population is based on the assertion that a sample size of 5 to 30 percent of the accessible population is appropriate for a descriptive survey [54]. Again, the sample size was deemed representative of the target population based on the recommendation that a sample size of 10% to 20% of the target population is representative in descriptive research [55].

Structured questionnaire, mathematics test items and unstructured observation schedule developed by the researcher were used to collect data for the study. These instruments were used because of the explorative and descriptive nature of the study. The questionnaire had a reliability coefficient (r) of 0.895 using Cronbach Alpha reliability analysis via the Statistical Package for Social Sciences (SPSS) software version 22. The instrument was pilot tested on twenty (20) level 200 students from Ada College of Education which did not form part of the actual field study. Secondary data was also collected in the form of mathematics test results from Institute of Education at University of Cape Coast. The data were described using descriptive statistics (frequency count, percentage) as well as inferential statistics (Pearson's correlation, multiple regression, exploratory factor analysis [EFA]) were computed at a significance level (p-value) of $p \leq 0.05$ (2-tailed) at a confidence interval (C.I) of 95% with a margin of error of ± 5. The data analysis was done SPSS software version 22.

Results

Background information

Table 1. Background information of respondents (n = 998)

Variable	**Frequency**	**%**
Sex		
Male	645	65
Female	353	35
Age (yrs.)		
18 - 22	500	50
23 - 27	464	47
28 & above	34	3

It is observed in Table 1 that more male (n = 645, 65%) than female (n = 353, 35%) pre-service teachers were used for the study. This result suggests that there were more male than female students in public colleges of education in Ghana. About half of the respondent sample (n= 500, 50%) were between ages 18 to 22, ages 23 to 27 years constituted 47% (n=464), whilst from age 28 and above constituted 3% (n=34). With regard to entry level grade in mathematics, the data collected and analysed indicated that many of the pre-service teachers (n = 947, 95%) had good entry grades of A1, B2, B3, C4, C5 and C6.

The factors influencing mathematical knowledge for teaching (MKT) of pre-service teachers in Ghanaian colleges of education

In order to find the plausible factors that influence pre-service teachers' MKT, Pearson's correlation was done to analyse the relationship between pre-service teachers' attitude, perception about mathematics as a subject and perception about mathematics teaching and learning, ways of imparting mathematical knowledge and mathematics performance. A scatter plot was used in the representation of the relationships between the variables or factors. The scatter plot in Figures 3 and 4 illustrate 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 launched by Shulman and his colleagues that good mathematics performance demands positive attitude and hands on activities [20]. This explains why National Teachers Council and stakeholders in teacher education are eager to set requirements based on national teachers' standards in Ghana.

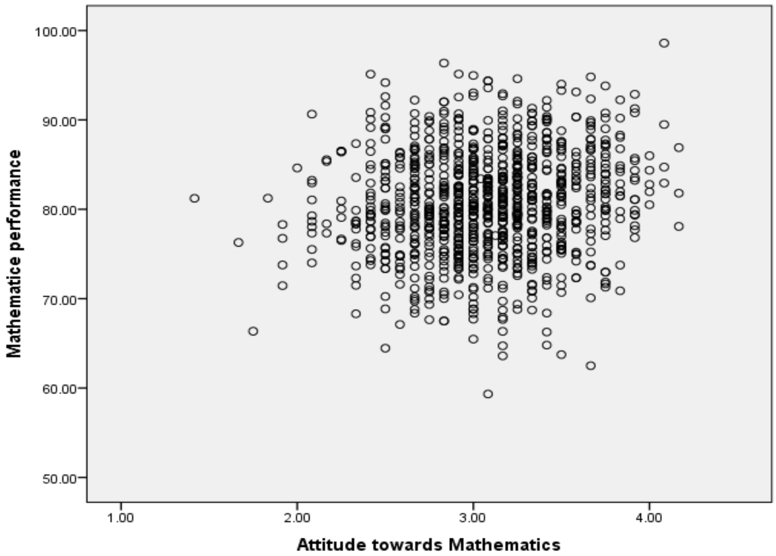

Figure 3. Scatter plot between mathematics performance and attitudes of mathematics teachers

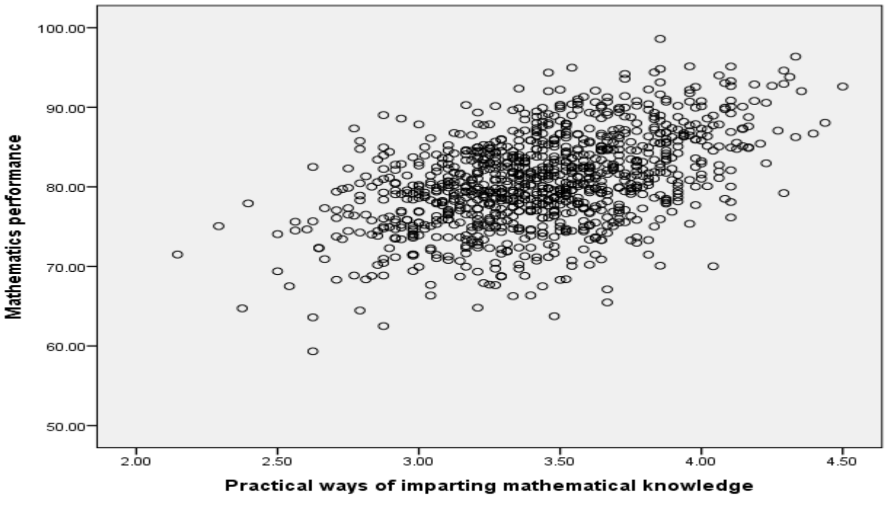

Figure 4. Scatter plot between mathematic performance and practical ways of imparting mathematical knowledge

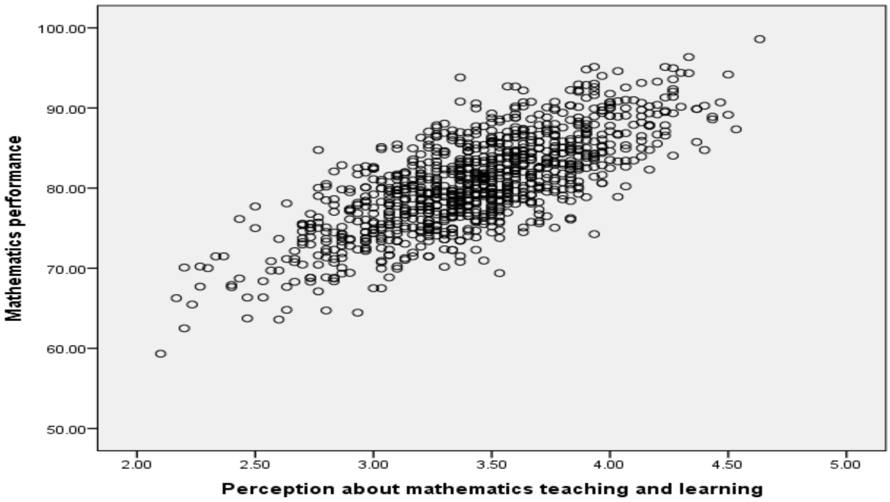

Figure 5. Scatter plot between mathematic performance and perception about mathematics teaching and learning

As it is recorded from the correlation analyses, it could be seen that there is a positive relationship between pre-service teachers' attitudes towards mathematics, practical ways of imparting mathematical knowledge, perception about mathematics as a subject and perception about mathematics teaching and learning, on their mathematics performance. A five-stage hierarchical multiple regressions were conducted with mathematics performance as the dependent variable to ascertain the established relationship from the correlation analyses. Demographics were entered at stage one of the regression model as a controlled variable. The pre-service teachers' attitudes towards mathematics were entered at stage two, whiles practical ways of imparting mathematical knowledge onto pre-service teachers at college and pupils in basic schools at stage three. Perception about mathematics as a subject was entered at stage 4 and finally, perception about mathematics teaching and learning was entered at stage 5.

Table 2. Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.145[a]	.021	.018	6.25553	.021	7.078	3	994	.001
2	.187[b]	.035	.030	6.21698	.014	7.183	2	992	.001
3	.525[c]	.276	.270	5.39518	.241	82.305	4	988	.001
4	.532[d]	.283	.275	5.37357	.007	4.982	2	986	.007
5	.900[e]	.811	.808	2.76838	.527	546.786	5	981	.001

Table 3. ANOVA

Model		Sum of Squares	df	Mean Square	F	p-value
1	Regression	830.972	3	276.991	7.078	.001
	Residual	38896.908	994	39.132		
	Total	39727.881	997			
2	Regression	1386.202	5	277.240	7.173	.001
	Residual	38341.679	992	38.651		
	Total	39727.881	997			

3	Regression	10969.174	9	1218.797	41.872	.001
	Residual	28758.706	988	29.108		
	Total	39727.881	997			
4	Regression	11256.882	11	1023.353	35.440	.001
	Residual	28470.999	986	28.875		
	Total	39727.881	997			
5	Regression	32209.556	16	2013.097	262.671	.001
	Residual	7518.325	981	7.664		
	Total	39727.881	997			

From the model summary and ANOVA, it was revealed that at model one, demographics contributed significantly to the regression model, $(F\ (3{,}998)\ =\ 7.078, P = .001)$ and accounted for 2.1% of the variation in mathematics performance. Introducing pre-service teachers' attitudes towards mathematics variables explained an additional 1.4% of variation in mathematics performance and this change in R-square was significant$(F\ (2{,}992)\ =\ 7.183, P =$ $.001)$. Adding practical ways of imparting mathematical knowledge onto pre-service teachers at college and pupils in basic schools' variables to the regression model explained an additional 24.1% of the variation in mathematics performance and this change in R^2 was significant,$(F(4{,}988)\ =\ 82.305, P\ =\ .001)$. When perception about mathematics as a subject variable was added to the model, the regression model explained an additional 0.7% of the variation in mathematics performance and this change in R^2 was significant, $(F(2{,}986)\ =$ $0000, P\ =\ .007)$. And when perception about mathematics teaching and learning was added to the model, the regression model explained an additional 52.7% of the variation in mathematics performance and this change in R^2 was significant,$(F\ (5{,}981)\ =\ 546.786, P\ =\ .001)$. When all the independent variables were included in model five of the regression, the independent variables were jointly significant$(F\ (16{,}981)\ =$ $262.671, P\ =\ .001)$, explaining 81.1% of variation in mathematics performance

Table 4. Coefficients of hierarchical multiple regression

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**p-value**
		B	**Std. Error**	**Beta**		
1	(Constant)	75.930	.623		121.820	0.001
	Gender					
	Female	reference point				
	Male	2.382	.598	.128	3.986	.001
	Age group					
	18 to 22 years	reference point				
	23 to 27 years	-.461	.412	-.036	-1.118	.264
	28 and above	-1.812	1.109	-.052	-1.633	.103
2	(Constant)	70.942	1.536		46.181	.001
	Gender					
	Female	reference point				
	Male	2.305	.594	.124	3.879	**.001**

	Age group					
	18 to 22 years	reference point				
	23 to 27 years	-.479	.410	-.038	-1.168	.243
	28 and above	-1.778	1.103	-.051	-1.611	.107
	Pre-service teachers attitude towards mathematics					
	F1	1.020	.293	.109	3.482	.001
	F2	.572	.363	.049	1.576	.115
3	(Constant)	47.800	2.385		20.042	.001
	Gender					
	Female	reference point				
	Male	2.475	.516	.133	4.793	.001
	Age group					
	18 to 22 years	reference point				
	23 to 27 years	-.376	.356	-.030	-1.058	.290
	28 and above	-.653	.962	-.019	-.679	.497
	Pre-service teachers' attitude towards mathematics					
	F1	1.056	.254	.113	4.155	.000
	F2	.097	.317	.008	.306	.760
	Practical ways of imparting mathematical knowledge					
	F1	2.476	.222	.304	11.162	.001
	F2	2.181	.178	.332	12.252	.001
	F3	.459	.433	.029	1.062	.289
	F4	1.953	.284	.188	6.888	.001
4	(Constant)	39.254	3.646		10.766	.001
	Gender					
	Female	reference point				
	Male	2.483	.515	.134	4.825	.001
	Age group					
	18 to 22 years	reference point				
	23 to 27 years	-.358	.355	-.028	-1.010	.313
	28 and above	-.579	.959	-.017	-.604	.546
	Pre-service teachers' attitude towards mathematics					
	F1	1.046	.253	.111	4.128	.001
	F2	.101	.316	.009	.318	.750
	Practical ways of imparting mathematical knowledge					
	F1	2.506	.221	.308	11.317	.001
	F2	2.182	.177	.332	12.307	.001
	F3	.426	.431	.027	.988	.323
	F4	2.009	.293	.193	6.852	.001
	Perception about mathematics as a subject					
	F7	.776	.513	.042	1.513	.131
	F8	1.578	.540	.081	2.924	.004
5	(Constant)	-2.225	2.107		-1.056	.291
	Gender					
	Female	reference point				

	Male	2.692	.265	.145	10.145	.001
	Age group					
	18 to 22 years	reference point				
	23 to 27 years	.172	.183	.014	.939	.348
	28 and above	.269	.497	.008	.542	.588
	Pre-service teachers attitude towards mathematics					
	F1	1.405	.131	.150	10.725	.001
	F2	.406	.163	.035	2.488	.013
	Practical ways of imparting mathematical knowledge					
	F1	2.527	.115	.311	22.047	.001
	F2	2.348	.092	.358	25.662	.001
	F3	-.221	.222	-.014	-.994	.321
	F4	2.203	.151	.212	14.576	.001
	Perception about mathematics as a subject					
	F1	1.264	.265	.069	4.762	.001
	F2	1.811	.278	.093	6.507	.001
	Perception about mathematics teaching and learning					
	F1	.149	.134	.018	1.105	.269
	F2	2.149	.178	.259	12.097	.001
	F3	2.319	.259	.209	8.959	.001
	F4	2.951	.134	.309	22.016	.001
	F5	2.865	.126	.432	22.728	.001

From Table 4, it can be seen that gender significantly predicts mathematics performance. Male pre-service teachers performed better in mathematics than female counterparts. The other variables that significantly predict mathematics performance were attitudes towards mathematics, practical ways of imparting mathematical knowledge (Factor 1, Factor 2 and Factor 4), perception about mathematics as a subject and perception about mathematics teaching and learning (Factor 2, Factor 3, Factor 4 and Factor 5). Factor analyses was also run to modify the plausible factors by reducing the number of entries that constitute the various factors analysed.

Table 5. KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.951
Bartlett's Test of Sphericity	Approx. Chi-square	2.232E4
	p-value	0.001

Table 5 presents the KMO test which measures the ratio of the squared correlation and the squared partial correlation between variables. For an appropriate data, the value should exceed 0.6. Bartlett's test tests if the correlation matrix is an identity matrix. However, we want to have correlated variables, so the off-diagonal elements should not be zero (0). Thus, the test should be significant. From Table 5, the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) value is 0.951, and the Bartlett's test is significant$(p - value = 0.001)$. This is indicative that factor analysis used was appropriate.

Discussions

The study found that many of the pre-service teachers (n = 947, 95%) had good entry grades (A1, B2, B3, C4, C5 and C6), but it did not reflect in their mathematics foundation courses as well as their mathematics professional course to build their MKT. This confirms the inadequacy of

MKT of pre-service teachers as reported by researchers in the West [56, 57, 58, 59, 60, 61]. The increase in predictive power of MKT for increased alignment of high performance in mathematics in the basic school supports the recommendation of researchers [31,56] who use the term mathematical content for teaching, and conforms to the recommendations of authors [62, 63] that prospective programs need to account for the weak mathematics knowledge of substantial portions of pre-service teachers.

It could be concluded from the results that the following factors influenced MKT of pre-service teachers: gender, ways of imparting mathematics knowledge, perception about mathematics as a subject, perception about mathematics teaching and learning and attitudes towards mathematics ($p < .05$). These findings validate the views of several researchers who averred that pre-service teachers' attitudes influence their approach in learning how to teach [64], the way they will teach in the future [65], and the classroom ethos [36, 65]. It has been argued that teachers' attitudes to mathematics may influence their enthusiasm and confidence to teaching the subject [36].

Conclusions

The entry behavior with regard to the grades in mathematics of many pre-service teachers in Ghanaian public colleges of education seemed good. Nonetheless, this does not reflection in their mathematics foundation courses as well as their mathematics professional course in college to build their MKT. This implies that pre-service teachers in Ghanaian colleges of education are likely to have weak mathematics knowledge for teaching mathematics in basic schools after completion of their course of study. In view of the above findings, the study makes the following recommendations:

1. Mathematics tutors in Ghanaian colleges of education should organize remedial lessons for pre-service teachers to scale-up their mathematics content knowledge, procedural and pedagogical knowledge. This would step up their mathematical knowledge for teaching (MKT) mathematics in Ghanaian Basic schools.
2. The National Council for Tertiary Education (NCTE) of Ghana should review the mathematics curriculum for colleges of education with regard to shedding light on the effect of values on MKT.
3. The Ghana Education Service should carry out continuous professional development programmes for in-service mathematics teachers to strengthen their mathematical knowledge for teaching (MKT) with regard to perception about the subject, attitude to pedagogy and assessment and constant reminder of gender equality and social inclusion.

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