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## AN ASSESSMENT OF PRESERVICE TEACHERS' CONTENT KNOWLEDGE FOR TEACHING ALGEBRA: EVIDENCE FROM GHANA'S CENTRAL REGION

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### Abstract

Teachers' content knowledge plays a pivotal role in the development of mathematical knowledge for teaching. This paper investigates pre-service teacher (PST) content knowledge for teaching Algebra. The study adopts a quantitative descriptive survey design. Seventy-nine (79) second-year pre-service teachers were selected as participants, from two Colleges of Education in the Central Region of Ghana. Content Knowledge Test in Algebra (CTA) and a questionnaire were used in generating data. Analysis of PST responses to the CTA showed that pre-service teachers' content knowledge for handling algebraic concepts in mathematics was superficial. Among other things, the study also found methods of teaching, previous algebraic content knowledge of pre-service teachers, level of interest, pre-service teachers' first-year performance in mathematics, and lack of practice as factors which hinder pre-service teachers' content knowledge in algebra. We conclude that mathematics teachers at the high school level should pay attention to their students' algebraic knowledge since algebra forms the basis of mathematics and it is at this level that a strong foundation is laid for higher education.

**Keywords:** Preservice teachers, Algebra, Content knowledge, Teaching, Mathematics

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### Introduction

Like many developing countries, Ghana has a standing record of poor learners' performance, particularly in Mathematics. Both national (Basic Education Certificate Examination) and international (TIMSS) assessments have highlighted the low level of learners' performance in Mathematics in the country (Buabeng et al., 2014). According to research, this is due to pre-service teachers' lack of content knowledge (CK) (Anamuah-Mensah et al., 2008; Ntow et al., 2009; Obeng et al., 2003). Two major tensions in Mathematics teacher education negatively affect pre-service teachers' understanding of how to effectively teach Mathematics (Ball, 1990). According to Wilmot (2008), the two tensions are: (i) pre-service teachers' lack of subject matter understanding, and (ii) the duration of pedagogical courses. Contributing to the debate, Acheampong and Furlong (2003) argued that graduates of Colleges of Education (where teachers are trained) are ill-prepared to facilitate learning in primary schools. One of the key teaching goals is to instill essential changes in the learner; therefore, a teacher must be well-versed in the subject matter they are teaching. A more knowledgeable teacher is more likely to present Mathematics problems in familiar contexts and link problems to learners' existing knowledge. Content knowledge (CK) describes the subject matter knowledge required of a content specialist, as defined by Shulman (1986). The United States Department of Education (2002) defines teachers' content knowledge as general Mathematics ability. Thus, the action sequence of solving mathematical problems is characterised by using several different constructs, including semantic, nets, and hierarchies' mental models (Bryan, 1999). This paper examines pre-service teachers (PST) content knowledge for teaching algebra. The research was motivated by the low performance of Ghanaian learners in mathematics, reported in the 2012 Chief Examiners Report for the Basic Education Certificate Examination (BECE) and noted by Oduro (2015). Again, there is a paucity of studies on the phenomenon. Previous studies within the Ghanaian context have focused on geometric transformation (Pinamang & Cofie, 2017).

Given its role in mathematics as well as its role as a gatekeeper to future educational and employment opportunities, algebra has become a focal point of both reform and research efforts in mathematics education (Knuth et al., 2006). Teachers' CK in Algebra is vital for the development of learners' algebraic thinking skills. Again, adequate content knowledge in Algebra is helpful in other mathematical topics such as Calculus, Engineering, Science, and Technology. The present study, therefore, attempts to answer the following questions:

1. To what extent is pre-service teachers' content knowledge adequate to handle Algebra at the Basic level?
2. What factors or characteristics are responsible for pre-service teachers' weak or high content knowledge in Algebra?

The amount of subject matter knowledge (SKM) and expertise possessed by teachers have been shown to significantly impact the quality of their instruction (Charalambous, 2010; Chen & Rovegno, 2000). Teachers' subject matter knowledge is essential in teaching Mathematics because it allows them to present problems in contexts that are familiar to students and connect mathematical tasks to what they already know, as SMK is an important indicator of students' learning outcomes. Many researchers have investigated pre-service teachers' knowledge, and understanding of mathematics as related concerns have been expressed by many as part of the problems facing mathematics learning. For example, Ball (1990) found that prospective teachers' substantive knowledge and understanding of division is procedural and rule-bound rather than conceptual in her study. Her study looked at prospective teachers' knowledge and understanding of division in three different mathematical contexts: division with fractions, division with zero, and division. Baturo and Nason (1996) studied pre-service teachers' knowledge of the area and concluded that the impoverished nature of the teachers' area subject matter limits their ability to help their learners develop an integrated and meaningful understanding of mathematical concepts and processes. According to Graeber (1999), there is a clear link between PST subject matter knowledge and alternative representation success in assisting learners in achieving conceptual understanding. When PST subject matter knowledge is insufficient, mathematics teaching becomes procedural. As a result, pre-service teachers must have sufficient subject-matter knowledge to deal with real-world issues in the classroom.

### Methodology

The study adopted a quantitative descriptive survey design for data generation. Simple random sampling was used to select 80 second-year pre-service teachers (PST). The rationale for choosing the second-year pre-service teachers was that they were a year and some months into their training programme and that they have covered most of the algebraic concepts at that point. First and third years were excluded from the data generation because, at the time of data collection, the first years were only a few months into their teacher training while the third years were out of campus for teaching practice (TP). Data to gauge PST content knowledge in algebra was obtained from respondents' responses to Content Knowledge Test in Algebra (CTA) and questionnaire. The CTA consists of 20 multiple-choice items from the past West African Certificate Examination. It contained questions on relations and functions, algebraic expression, and indices with four options per item that was used to determine pre-service teachers' achievement and content knowledge in algebra. The questionnaire item had three sections designed with a five-point Likert scale ranging from 1 Not at all to 5, very well. The first section of the questionnaire focused on the demographic profile of the pre-service teachers containing three items. Section 2 of the questionnaire contained three items aimed at exploring PSTs' algebra content coverage and their level of understanding of selected algebraic contents contained in the teacher colleges' curriculum. The third section contained five items meant to investigate factors PSTs perceived to be influencing their content knowledge on algebra. To check the validity, the instruments were given to two experts for comments and suggestions. The expert's suggestions and comments were incorporated and considered for further improvement. For the reliability of each item, we conducted a pilot study among 20 PSTs with the same characteristics as the study participants but from different teacher colleges. As recommended by McMillan and Schumacher (2001). According to McMillan and Schumacher, a sample size of twenty (20) or more is sufficient for a pilot study. Cronbach's alpha value of 0.78 was obtained which was acceptable.

**Table 1: The reliability test for the questionnaire**

Reliability Statistics		
Cronbach's alpha	Cronbach's Alpha Based on Standardised Items	N of items
	0.78	20

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Descriptive statistics (percentages, means and standard deviations) were used to present pre-service teachers' content knowledge for teaching Algebra. Participants' responses to the CTA were scored out of twenty (20) marks. The questionnaire responses were also coded using numerical codes. The Achievement Test in Algebra scores and the responses from the questionnaire were captured in the Statistical Package for Social Sciences (SPSS). The numerical scores and codes of responses for each participant were recorded as separate entries. Statistical analysis was conducted, and simple descriptive statistics such as frequency, percentages, and means were obtained

## Results

**Table 2: Background characteristics of participants**

Characteristics	Number	Percent
Sex		
Male	45	57
Female	34	43
Age ( years)		
< 20	12	15.2
21 – 25	63	79.7
>25	4	5.1
Mean (SD)	22.5 (2.2)	
Type of maths course offered at high school		
Core Mathematics	51	64.6
Elective Mathematics	28	35.4

Participants' background characteristics are presented in Table 2. Out of the 80 questionnaires that were administered, a copy of the questionnaire was rejected for incompleteness. We analysed 79 questionnaires. Out of the 79 pre-service teachers, 45 (57%) were males. The remaining 34 (43%) were females. A majority, 63 (79.7%) of the participants, were in the age range of 21 – 25 years, while 12 (15.2%) were below 21 years. Only 4 (5.1%) were above 25 years. The mean age of pre-service teachers in this study was 22.5 (SD = 2.2) years. Among the participants, 28 (35.4%) offered Elective mathematics. Again, the majority, 51 (64.6%), offered Core mathematics (In Ghana, core mathematics is a generic course for all learners at the high school level).

**Table 3: Pre-service teachers' Knowledge and algebraic content coverage**

Subject Matter: Conetnt	Taught Number (%)	Not Taught Number (%)
Sets and Operations on set	60(75.9)	19(24.1)
Real Number System	66(83.5)	13(16.5)
Surds, Indices and Logarithms	78(98.7)	1 (1.3)
Equations and Inequalities	76(96.2)	3 (3.8)
Polynomials	49(62.0)	30(38)
Relations and Functions	72(91.1)	7 ( 8.9)
Algebraic Expressions	67(97.1)	12 (2.9)

Table 3 presents a descriptive summary of pre-service teachers' background knowledge and coverage of algebraic subject matter carefully selected from the school curriculum. Participants were to indicate whether they have received tuition or they have not on the selected topics. While 19 (24.1%) indicated that they had not received tuition on the concept sets and operations on set, slightly over three-fourths, 60 (75.9%) of the participants responded that they had received lessons on sets and operations on set. Concerning the real number system, out of 79 pre-service teachers, 66 (83.5%) responded that they were taught, while 13 (16.5%) answered that they were not taught. The majority, 78 (98.7%), of pre-service teachers also responded that they were taught surds, indices, and logarithms. The result also indicated that 96.2% (76), 62% (49), 91.1% (72), and 97.1% (67) of the pre-service teachers responded that they had received instruction on Equations and Inequalities, Polynomials, Relations, and Functions, as well as Algebraic Expressions respectively. In comparison, 1.3%, 3.8%, 38%, 8.9%, and 2.9%, respectively, responded that they had not been taught those aspects in algebra.

**Table 4: Pre-service teachers' adequacy of algebraic content**

Subject Matter: Content	Mean	Std. Dev
Sets	3.49	1.48
Real Number System	3.51	1.50
Surds	3.41	1.40
Indices	3.82	1.30
Logarithm	4.01	1.27
Quadratic Equations and Functions	4.03	1.32
Algebraic Expression	3.68	1.45
Difference of two squares	3.79	1.26
Change of Subject	4.10	1.16

In establishing and classifying whether participants have the required content knowledge for teaching algebra, mean and standard deviation of various algebraic concepts were used. Drawing from previous studies (Ikediashi et al., 2012; Wang & Yuan, 2011), a mean value of 3.0 was acknowledged as the acceptable yardstick. In this study, a mean of 3.0 for each algebraic concept indicates adequate content knowledge for teaching that particular subject matter. If two or more items have the same mean, the item with the least standard deviation is considered more critical (Wang & Yuan, 2011). This is because the items under each of the categories are on a 5- point Likert scale, where 1 is the minimum score associated with the item and 5 is the maximum score. Analysis of pre-service teachers' level of understanding concerning eight selected concepts in algebra is presented in Table 4. The result shown in Table 4 reveals that PSTs' knowledge of algebraic concepts is high. This was evident in the mean scores of the various content areas which were above the established yardstick (3.0). Thus, “*change of subject*”, “*quadratic equations and Function*”, and “*Logarithm*” are considered as the algebraic concepts that received high scores indicating that participants have higher content knowledge on this subject matter. These concepts recorded relatively higher scores ranging from 4.01 to 4.10 exceeding the acceptable yardstick mean value of (3.0). Indices, the difference of two squares and algebraic expressions, were also important concepts participants had a good understanding of. In summary, the results in Table 4 show that pre-service teachers who participated in this study had a very high content knowledge of algebraic concepts.

**Table 5: Distributions of Pre-Service Teachers' CTA Scores**

Marks	Percentage (No. of PST)	Grade
80 – 100	19.29 (15)	A
75 – 79	3.85 (3)	B+
70 – 74	3.85 (3)	B
65 – 69	10.26 (8)	C+
60 – 64	8.97 (7)	C
55 – 59	10.26 (8)	D+
50 – 54	5.12 (4)	D
0 – 49	38.46 (30)	E

Previous knowledge of relevant subject matter should have a positive bearing on one's present academic work. Tobias (1994) identified prior knowledge of the learner as the most important factor influencing learning and students achievement. The result in Table 5 shows that PSTs' content knowledge or their understanding level of algebraic concepts is high and therefore should translate into their performance in the CTA (Content Knowledge Test in Algebra). However, analysis of participants CTA scripts using the grading system of Colleges of Education with a pass mark of 60% showed a different picture. Table 5, shows an analysis of pre-service teachers' content knowledge test scores in algebra. The majority, 42 (54%) of the participants scored below the pass mark. In other words, 54% of the pre-service teachers failed the CTA with the remaining 36 (46%) passing. Since the majority scored below C (60 -64) %, we conclude that PST who participated in the study have weak content knowledge in algebra.

**Table 6: Factors influencing preservice teachers' content knowledge in Algebra**

Factors	Mean(x)	Std. Dev
Methods used in teaching maths	0.68	0.47
Maths content knowledge from SHS	0.67	0.47
Level of interest in maths	0.66	0.48
Maths performance from first year	0.48	0.50
Lack of practice	0.39	0.49

The factors perceived to be influencing pre-service teachers' Mathematical knowledge in Algebra are presented in Table 6. Participants indicated that the method used in teaching mathematics (Mean = 0.68, Std. deviation = 0.47) was the major determinant of their algebraic content knowledge. Following the method of instruction is the content knowledge acquired during their secondary education (Mean = 0.67, Std. deviation = 0.47). Furthermore, participants recognised interest level in Mathematics (Mean = 0.66, Std. deviation = 0.47) and first-year mathematics performance (Mean= 0.48, Std. deviation = 0.50) as other factors which influence their competency level in Algebra.

### Discussion

To carry out the task of teaching, a teacher needs an appreciable understanding of the subject matter. Teachers' Content knowledge plays a positive role in the development of Mathematical knowledge for teaching (Nsiah-Asante & Mereku, 2012). However, the results of this study raise concerns about the teaching of Mathematics by pre-service mathematics teachers whose knowledge of Algebra is so poor. The results in (table 4) reveal that pre-service teachers rated their content knowledge in algebra as high. One would expect that they have the high content knowledge to translate into good performance in Algebra. However, it was observed that pre-service teachers who had a higher rating in algebraic content obtained relatively poorer marks on the CTA test. It can be explained from the trend of the results that pre-service teachers' content knowledge to handle Algebra at the basic school level after their training is inadequate. This finding corroborates McAuliffe and Lubben (2013)'s findings. Exploring primary school teachers' content knowledge of early algebra, McAuliffe and Lubben (2013) found that teachers' subject matter knowledge for teaching algebra was not fully established and that there were shortcomings in their ability to describe procedures utilised by learners, analyse learners' errors and interpret learners' productions. Assessing factors influencing PSTs' content knowledge of algebra, five factors were identified. The study further revealed that pre-service teachers' subject matter knowledge in algebra is influenced by five factors; methods of teaching, PST content knowledge from SHS, their level of interest in mathematics, PST first-year performance in mathematics with lack of practice identified as the least factor which affects PST content knowledge in algebra. Across the various factors, it was found that the method of instruction was the major factor identified. This finding is in consonance with Mereku (2004)'s observation that lack of confidence and lack of using prescribed methods of teaching influences teachers' content knowledge for teaching mathematics.

### Conclusion

These results call for introspection into the Mathematics training offered in the Colleges of Education in Ghana. The findings have important implications for mathematics teaching and learning. When PST become in-service professionals, they are likely to have a lot to think about when it comes to how to teach and how well they know the subject matter they are supposed to teach.

### Recommendations

In light of this, we recommend that:

1. High school students should be taught more than how to simply pass tests. They should also be taught how to understand different algebraic concepts and what they should know because this is where a strong foundation is built for a college education.
2. Colleges of Education curricula should integrate both content and pedagogy so that pre-service teachers will be able to familiarize themselves with the various teaching methods of various concepts right from the beginning of their training.

## References

- Acheampong, A. K., & Furlong, D. (2003). *A baseline study of the teacher education system*. Sussex: Centre for International Education, University of Sussex.
- Anamuah-Mensah, J., Mereku, D. K., & Ghartey-Ampiah, J. (2008). Ghana Junior Secondary School Students' Achievement in Mathematics and Science: Report from Ghana's Participation in 2007 trend in International Mathematics and Science Study. Accra: Ministry of Education Youth and Sports
- Ball, D. L. (1990). The mathematical understandings that prospective teachers bring to teacher education. *The Elementary School Journal*, 90(4).
- Batruo, A. & Nason, R. (1996). Student teachers' subject matter knowledge within the domain of area measurement. *Educational studies in mathematics*, (31), 253-268.
- Bryan, T. J. (1999). The Conceptual Knowledge of Pre-service Secondary Mathematics Teachers: How well do they know the subject matter they will teach? Issues in the Undergraduate Mathematics of School Teachers (Vol. 1).
- Buabeng, I., Owusu, K. A., & Ntow, F. D. (2014). TIMSS 2011 Science Assessment Results: A Review of Ghana's Performance. *Journal of Curriculum and Teaching*, 3(2), 1-12.
- Charalambous, C.Y. (2010). Mathematical knowledge for teaching and task unfolding: An exploratory study. *The Elementary School Journal* 110(3). 247-278.
- Chen, W., & Rovegno, I. (2000). Examination of expert and novice teachers' constructivist-oriented teaching practices using a movement approach to elementary physical education. *Research Quarterly for Exercise and Sport*, 71(4), 357-372.
- Graeber, A. O (1999). Forms of knowing mathematics: What pre-service teachers should learn. *An international journal*, (38), 189-209.
- Ikediashi, D. I., Ogunlana, S. O., Boateng, P., & Okwuashi, O. (2012). Analysis of risks associated with facilities management outsourcing. *Journal of Facilities Management*.
- Knuth, E. J., Stephens, A. C., McNeil, N. M., & Alibali, M. W. (2006). Does understanding the equal sign matter? Evidence from solving equations. *Journal for research in Mathematics Education*, 37(4), 297-312.
- McAuliffe, S., & Lubben, F. (2013). Perspectives on pre-service teacher knowledge for teaching early algebra. *Perspectives in Education*, 31(3), 155-169.
- McMillan, J. H., & Schumacher, S. (2001). *Research in education: A conceptual introduction* (5th ed.). Longman.
- Mereku, K. D. (2004). Methods in Ghanaian Primary Mathematics Textbooks and Teachers' Classroom Practice. *Research in Mathematics Education*, 6.157-173.
- Nsiah-Asante, J., & Mereku, D. K. (2012). The Effect of Ghanaian Pre-service Teachers' Content Knowledge on their Mathematical Knowledge for Teaching Basic School Mathematics. *African Journal of Educational Studies in Mathematics and Science*. 10, 23-37.
- Ntow, F. D., Tackie, N. A. & Sokpe, B. Y. (August 2009). Pre-service teachers' content knowledge for teaching basic school mathematics. *Mathematics Connection*. 8. 29-32.
- Obeng, A. E., Opare, A. J., & Dzinyela, M. J. (2003). A Case Study of the Centre for Research on Improving Quality of Primary Education in Ghana. Association for the Development of Education in Africa Biennial Conference.
- Oduro, E. O. (2015). *Assessment in mathematics classrooms in Ghana: a study of teachers' practices* (Doctoral dissertation, University of Sussex).
- Pinamang, I., & Cofie, P. O. (2017). Pre-service teachers' content knowledge and pedagogical content knowledge in teaching geometric transformation. *African Journal of Educational Studies in Mathematics and Sciences*, 13, 63-70.
- Shulman, L. S. (1986). Knowledge and Teaching: Foundations of New Reform. *Harvard Educational Review*, 1-22.
- Tobias, S. (1994). Interest, prior knowledge, and learning. *Review of educational Research*, 64(1), 37-54.
- U. S. Department of Education. (2002). Meeting the Highly Qualified Teachers Challenge. The Annual Report on Teacher Quality. Washington, DC: Department of Education, Office of Post-Secondary Education.
- Wang, J., & Yuan, H. (2011). Factors affecting contractors' risk attitudes in construction projects: case study from China", *International Journal of Project Management*, 29. 209-19.
- Wilmot, E. M. (2008). Learning to Teach Basic School Mathematics: Lessons from a Pedagogical Course. *African Journal of Educational Studies in Mathematics and Sciences*. 6, 1-13.