

## **Pre-service teachers' content knowledge and pedagogical content knowledge in teaching geometric transformation**

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### **Abstract**

This study investigated pre-service teachers' content and pedagogical knowledge in teaching geometric transformation. Eighty-two pre-service teachers from two Colleges of Education in the Ashanti region of Ghana consisted the sample size. The study was a quantitative study which employed survey as a strategy of enquiry with a Geometric Transformation Achievement Test (GTAT) as the instrument used for data collection. The GTAT was given to pre-service teachers to identify how knowledgeable they are in content and pedagogical knowledge in geometric transformation. The results indicated a high level of content knowledge but low level of pedagogical content knowledge among the pre-service teachers in geometric transformation. A correlation analysis was also performed to identify the relationship between pre-service teachers' content and pedagogical knowledge in geometric transformation and the results indicated a weak positive significant relationship between pre-service teachers' content knowledge and pedagogical content knowledge,  $r(82) = .044$ ,  $p < .05$ , two-tailed. It was therefore recommended that geometric transformation content and pedagogical courses at the Colleges of Education be made more practical and that pre-service teachers should be given ample opportunity to practice what they are going to teach at the basic level.

Keywords: content knowledge, pedagogical content knowledge, pre-service teachers, geometric transformation achievement test

### **Introduction**

Teacher Education in mathematics is noted to be embedded with two main tensions which negatively affects pre-service teachers attempt at learning to teach mathematics for understanding (Ball, 1990). The first of these tensions is attributed to pre-service teachers weak understanding of the subject matter and the second being the duration of the pedagogical courses (Wilmot, 2008). According to Darling-Hammond (2000), the key factor to students' academic success in today's classrooms solely rely on teachers' content and pedagogical knowledge. Because of this, the kind of knowledge desirable for mathematics teaching has interested researchers and many studies are being carried out to ascertain the effectiveness of teachers' content and pedagogical knowledge.

The United States' Department of Education (2002) referred to teachers' content knowledge as the general mathematics ability, thus, the action sequence of solving mathematical problems which to Bryan (1991) are characterized by using several different constructs including semantic nets, hierarchies and mental models. Shulman (1987) first proposed the concept of pedagogical content knowledge as a model for describing how teachers acquire new understanding of the content that they teach and how these understandings influence their teaching. To Jegede et al. (2000),

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pedagogical content knowledge can be explained as knowledge for teaching which includes the knowledge of approaches to school mathematics topics, teachers' knowledge of teaching procedures such as effective strategies for planning, classroom practices, organizational procedures and motivational techniques, thus, different ways of presenting mathematics (Rowan. Correnti & Miller, 2002).

In Ghana, teachers content and pedagogical knowledge are vital in the teaching of mathematics especially, geometry. Although, geometry is an important area in mathematics and much effort is exerted in teaching it but evidence from numerous research studies makes it clear that many students' geometrical understanding is not at the level they need or are expected to be (Mitchelmore & White, 2000). A report by Anamuah-Mensah, Mereku and Gharthey-Ampiah (2008), on the 2007 Trends in International Mathematics and Science studies (TIMSS) stated that, the performance of students in geometry as compared to the previous performance was declining. According to the report, students were examined on algebra, geometry, number, and data and chance, but in all the four mathematics content domains, the Ghanaian JHS2 students' performance was statistically significantly below the TIMSS scale average of 500 indicating that they were weak in all four domains. The report also indicated that more than half of these students were in schools where only twenty-six to twenty-seven percent of teachers had training in improving content knowledge and pedagogical skills.

Geometric Transformation as an aspect of geometry is taught as both content and pedagogy at the colleges of education. Its inclusion in the curriculum is to review and consolidate concepts and skills related to geometry, discover relations involving shapes and relating and applying mathematical knowledge to solve problems involving geometry by using appropriate procedures and skills (Teacher Education Division, 2010). The geometric transformation content areas focus on Rotation, Reflection, Translation, Enlargement and Reduction whilst pedagogical aspects of these areas are designed to prepare pre-service teachers to teach geometrical transformation at the basic levels of education in Ghana on completion of their programme, but, pre-service teachers face difficulties in these area as posited by Ntow, Tackie, and Sokpe (2009) that, for all the reported poor performance of pre-service teachers, it is these same pre-service teachers who come out to teach at the basic levels in Ghana. Currently, most pre-service teachers admitted into the Ghanaian Colleges of Education are mainly from the Senior High Schools in Ghana and a critical comparison of the mathematics curriculum of the Colleges of Education and that of the Senior High Schools indicates a lot of similarities in geometric transformation contents. Therefore, if indeed geometrical transformation contents at the Colleges of Education are similar to that of the Senior High schools and yet pre-service teachers still have difficulties in this area of geometry, then, there is the need to look into the content and pedagogical knowledge of these pre-service teachers in the area of geometric transformation.

### **Statement of the problem**

Most pre-service teachers do not show competency in content knowledge as well as pedagogical content knowledge in geometric transformation when they are deployed in schools. Acheampong and Furlong (1999) pointed out that graduates of teacher training colleges are ill-prepared in facilitating learning in basic schools. Obeng, Opore and Dzinyela (2003) also stated that trainees were not strong enough in subject matter content whilst Nsiah-Asante and Mereku (2012) threw

more light on pre-service teachers' poor content knowledge and pedagogical content knowledge by recommending that the mathematics pedagogy courses should be made more practical, and that, pre-service teachers should be given ample opportunity to practice more of what they are going to teach at the basic level.

Observation made by Anamuah-Mensah, Mereku and Ghartey-Ampiah (2008) with regard to the general performance of Ghanaian students' in mathematics from the Trends in International Mathematics and Science studies (TIMSS) 2007 report brings to light the teachers' delivery approach. According to Anamuah-Mensah et al. (2008), they were of the view that in Ghana, there seem to be rapid movement from one topic to another suggesting that the level of the subject taught was rather superficial, with students often failing to acquire deeper understanding of any particular topic.

#### *Purpose of the study and research questions*

The purpose of the study was to explore pre-service teachers' content and pedagogical knowledge for teaching geometric transformation at the Junior High School level and to identify the relationship between their content knowledge and pedagogical content knowledge in geometric transformation.

1. How knowledgeable are pre-service teachers in content and pedagogy in teaching geometric transformation?
2. What is the relationship between pre-service teachers' content knowledge (CK) and pedagogical content knowledge (PCK) in geometric transformation?

#### **Methodology**

The study was a quantitative research that employed survey as a strategy of enquiry. The survey involved the use of a Geometric Transformation Achievement Test (GTAT) to explore the content and pedagogical content knowledge of the pre-service teachers. The population was second year pre-service teachers in the Ashanti Region of Ghana. Two intact classes were randomly selected in two Colleges of Education to participate in the study. A total of 82 pre-service teachers (58 males and 24 females) consisted the sample size. The Geometric Transformations Achievement Test (GTAT) was given to pre-service teachers to identify their knowledge in content and pedagogical knowledge and also to identify the relationship between their content knowledge and pedagogical content knowledge with respect to geometric transformation. In all, 12 questions based on geometric transformation were answered by each pre-service teacher. In questions one to ten, pre-service teachers' content knowledge on geometric transformations was tested. The questions centred mainly on recall and application of geometrical transformation formulae. The questions were multiple choice questions and therefore pre-service teachers were expected to choose an answer from the provided options. Questions eleven and twelve also tested for pre-service teachers' pedagogical content knowledge on geometrical transformation. They were two main broad questions with sub-questions and pre-service teachers needed to apply practical knowledge to enable them solve these questions very well. The questions were supply type multiple choice questions and therefore pre-service teachers were expected to supply their own answer to all questions. Apart from questions 11 and 12, all other questions carried equal marks of one. However, in questions 11 and 12 each was awarded 5 marks as a result of the demand of these questions. The researcher personally collected the data by administering the instrument on the selected sample in the selected colleges of Education. Both descriptive and inferential analysis were used to analyzed the data collected.

## Results

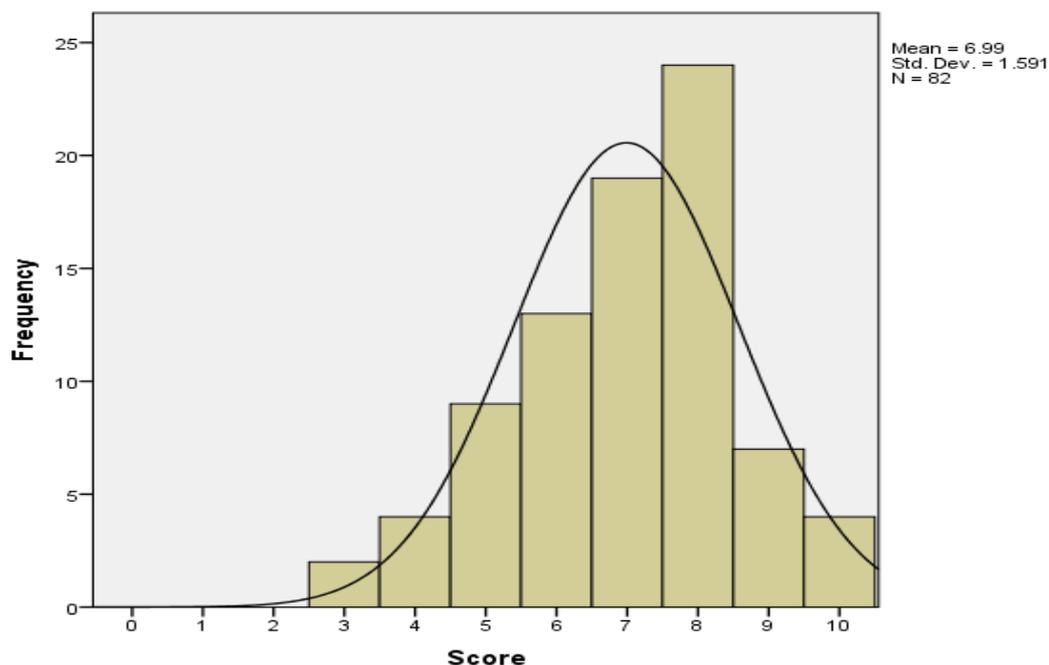
*Research Question 1: How knowledgeable are pre-service teachers in content and pedagogy in teaching geometric transformation?*

Considering the pre-service teachers content knowledge, Table 1 presents the descriptive statistics of the pre-service teachers' scores in the GTAT for their content knowledge.

**Table 1 Descriptive statistics of Pre-service Teachers scores in the GTAT for CK**

	N	Min	Max	Mean	S.D	Skewness
Score	82	3	10	6.99	1.59	-0.39

The results in Table 1 shows the descriptive statistics of the pre-service teachers scores in the GTAT for content knowledge. From Table 1, the highest score by the pre-service teachers on all the ten questions was 10 and the least score was 3 with a mode and median as high as, 8 and 7 respectively. The test recorded a mean of 6.99 with a standard deviation of 1.59. The descriptive statistics of students score is an indication that most of the pre-service teachers scored high marks.



**Figure 1 Overall performance of pre-service teachers in the content knowledge aspect of the GTAT**

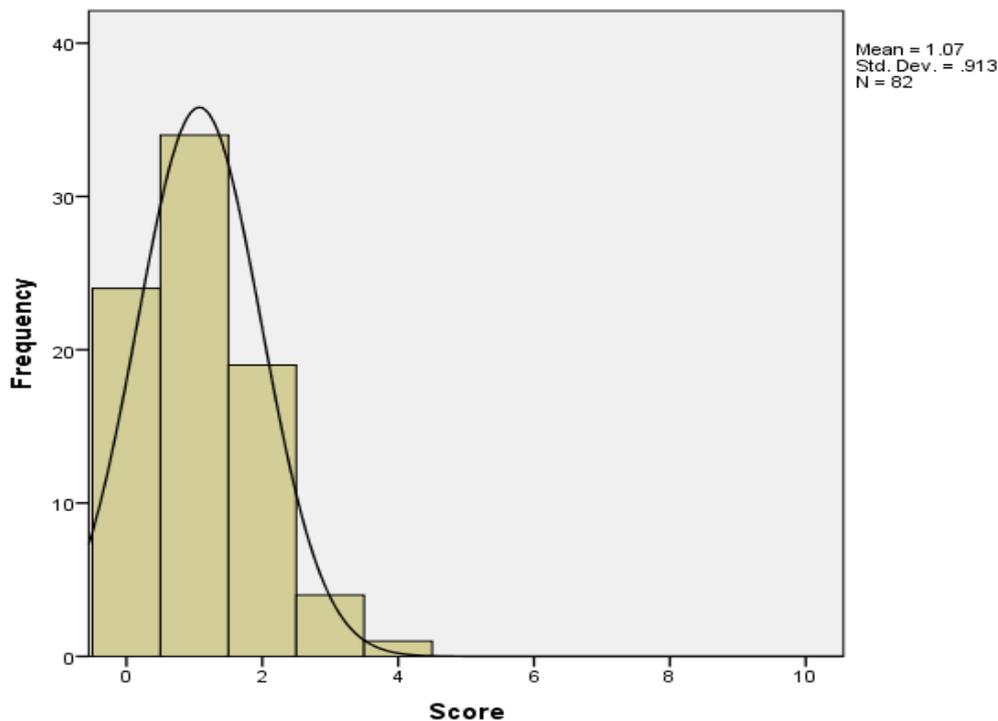
Figure 1 shows a summary of pre-service teachers' performance on the content knowledge (CK) aspect of the Geometric Transformation Achievement Test (GTAT). The graph shows a negatively skewed performance by students indicating that the overall performance of pre-service teachers

was high with most of them obtaining marks between 6 and 8 out of a total of 10. Considering the pre-service teachers’ pedagogical content knowledge (PCK), Table 2 presents the descriptive statistics of the pre-service teachers’ scores in the GTAT for their pedagogical content knowledge.

**Table 2 Descriptive statistics of Pre-service teachers scores in the GTAT for PCK**

Descriptive	N	Min	Max	Mean	Median	Mode	S.D	Skewness
Score	82	0	4	1.07			0.91	0.65

Table 2 shows the descriptive statistics of the pre-service teachers’ scores in the pedagogical content knowledge aspect of the Geometric Transformation Achievement Test (GTAT). From Table 2, the maximum score by the pre-service teachers on all the ten items was 4 and the minimum score was 0 with a mode and median as low as, 1 and 1 respectively. The test recorded a mean of 1.07 with a standard deviation of 0.91. The descriptive statistics of pre-service teachers score is an indication that most of them had very low marks.



**Figure 2 Performance of the pre-service teachers in the pedagogical content knowledge aspect of the GTAT**

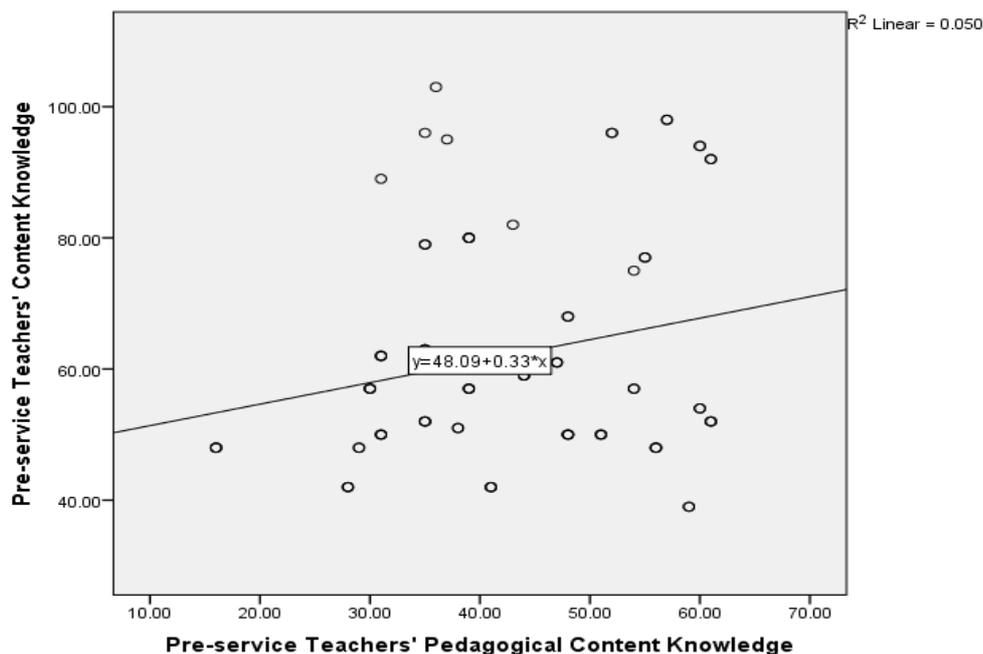
Figure 2 shows the overall performance of pre-service teachers in the Geometric Transformation Achievement test for their Pedagogical Content Knowledge. The graph shows a positively skewed performance by pre-service teachers indicating that the overall performance of pre-service teachers was abysmal with most of the students obtaining marks between 0 and 4.

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*Research Question 2: What is the relationship between pre-service teachers' content knowledge (CK) and pedagogical content knowledge (PCK) in geometric transformation?*

Research Question 2 sought to identify if there exist any relationship between Pre-service Teachers' content knowledge and pedagogical content knowledge in geometric transformation. A correlation analysis was performed to identify if such relationship exists. Figure 3 shows the Scatter Plot for the Relationship between Pre-service Teachers' Content Knowledge and Pedagogical Content Knowledge in geometric transformation.



**Figure 3** Scatter plot for the pre-service teachers' scores on CK and PCK aspects of the GTAT

**Table 3** Spearman's correlation for pre-service teachers' CK and PCK

Correlation	N	Spearman's Correlation	Sig.(2-tailed)
CK and PCK	82	.233	,044

The figure above shows a poor linear relationship between the pre-service teachers' content knowledge and pedagogical content knowledge. From the results Table 4 [ $r(82) = .044, p < .05$ ], it was observed that there was very little or no correlation between the pre-service teachers' scores in the pedagogical content knowledge and content knowledge aspects of the GTAT.

**Discussion**

The researcher investigated pre-service teachers' content knowledge and pedagogical content knowledge in geometric transformation. Considering the content knowledge, the pre-service

teachers exhibited deep content knowledge from the geometric transformation test and this contradicts to what Obeng, Opare and Dzinyela (2003) observed that trainees were not strong in subject matter content. Notwithstanding, the results from the pedagogical content knowledge aspect of the GTAT revealed the pre-service teachers had low pedagogical content knowledge in geometric transformation. This finding provides further evidence for the recommendations made by Nsiah-Asante and Mereku (2012) that mathematics pedagogy courses should be made more practical, and that, pre-service teachers should be given ample opportunity to practice what they are going to teach in the college classroom.

On the correlation analysis which was conducted to identify if there exist any relationship between the pre-service teachers' content knowledge and their pedagogical content knowledge in geometric transformations, the results indicated a direct positive relationship between the content knowledge and the pedagogical content knowledge. This result also confirmed what Ball (1990) said, that effective mathematics teaching is linked to both the teachers' content knowledge and pedagogical content knowledge.

### **Conclusion and recommendations**

From the analysis of the study, it can be concluded that pre-service teachers have deep content knowledge pertaining to geometric transformation since majority of them had higher marks in the Geometric Transformation Achievement Test for Content Knowledge. Also pre-service teachers have low pedagogical content knowledge in geometric transformation which was also ascertained by their poor performance in the Geometric Transformation Achievement Test for Pedagogical Content Knowledge. Furthermore, there is a direct positive significant relationship between pre-service-teachers content and pedagogical content knowledge with respect to geometric transformation.

Based on the conclusions, it is recommended that geometric transformation content knowledge and pedagogical content knowledge courses at the Colleges of Education should be made more practical and that pre-service teachers should be given ample opportunity to practice what they are going to teach at the basic level. This will reduce inadequate understanding of geometric concepts at the basic level.

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