
**PRE-SERVICE TEACHERS' USE OF PEDAGOGICAL CONTENT KNOWLEDGE IN
TEACHING AND LEARNING MATHEMATICS AT BASIC SEVEN IN AKATSI
DISTRICT, GHANA**

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ABSTRACT: *The purpose of the study is to explore how pre-service teachers' use their Pedagogical Content Knowledge (teachers' knowledge of content and students' thinking process) to identify and diagnose students' misconceptions in comparing, adding, multiplying and dividing fractions. Pre-service teachers were expected to identify students' misconceptions, give reasons of students' misconceptions, and ask specific questions to diagnose students' thinking processes that lead to the misconceptions. A total of 72 pre-service teachers teaching Mathematics were purposively selected out of 320 students from the schools of practice. Descriptive survey design was used for the study. Data collected were analyzed using frequencies, percentages and means. The study revealed that about 60% of the pre-service teachers could identify the students' misconceptions but only 17% of them could articulate the reasons for students' misconceptions clearly. Also about 58% of the pre-service teachers asked probing questions instead of specific questions to diagnose students' misconceptions and only about 14% of them asked specific questions. It was concluded that most of the pre-service teachers were able to identify students' misconception but could not give reasons for the students' misconceptions. In addition, majority of the pre-service teachers could not ask specific questions to diagnose students' misconceptions. It was recommended that teacher training institutions integrate pedagogical content knowledge in to the curriculum to equip pre-service teachers with skills that would enable them to analyze students' thinking processes.*

KEYWORDS: Pre-Service, Pedagogical Content, Knowledge, Teaching and Learning, Mathematics, Akatsi District, Ghana

INTRODUCTION

Teacher education in Ghana has been going through a process of change and development. This change and development is taking place in response to the need to provide quality teachers for the

education of the youth at all levels of the country's educational system. Notwithstanding the need for quality teachers, newly trained teachers in Ghana are ill prepared to handle the new direction of the curriculum that was put in place in Primary and Junior Secondary Schools (MOE, 1996; Pecku, 1998). As a result, Ghana Education Service has established Teacher Education Division to make sure that the thrust of pre-service Teacher Education (TE) programmes in Ghana develop a teacher who is knowledgeable in the subject areas, and fundamental skills of teaching. In effect, pre-service teachers should possess a critical mass of pedagogical content skills and knowledge which are considered essential to the promotion of children's learning in the classrooms. Lockheed and Verspoor (1991) also emphasized that effective pre-service training need to build on a sound knowledge of the curriculum, pedagogical skills and practice teaching under the supervision of an experienced and capable teacher.

The study on Developing Science, Mathematics, and ICT (SMICT) in Ghana, considered pre-service teachers' pedagogical content knowledge observed that pre-service teacher preparation in pedagogical content knowledge (PCK) was teacher centered, and that much drill-and- practice teaching of algorithms and verbal knowledge was taking place. Such teaching styles, coupled with lack of awareness and knowledge as to how to address students' conceptual errors, lead to superficial learning based on recall and not on comprehension (Ottevanger, Akker & Feiter, 2007)

Pre-service teachers were often presented with unique challenges. The challenges of pre-service teachers usually start when they experience difficulty transferring theory and knowledge from college preparation programs into practical application within the classroom (Darling-Hammond, 2010; Feiman-Nemser, 2012). Preparation programs often failed to translate effectively into classrooms (Panesar, 2010). Pre-service teachers have incomplete and superficial levels of pedagogical content knowledge (Carpenter, Fennema, Petersen & Carey, 1998).

According to Langrall, Thornton, Jones and Malone (1996) methods instructors needed to influence pre-service teachers' beliefs in a positive way if they consistently encouraged

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individuals and collaborative groups to reflect on a limited but powerful set of pedagogical content knowledge principles. This is because pre-service teachers continually transform pedagogical content by integrating new experiences with what they understand about teaching (Cochran et al, 1993). Kennedy (2001) was of the view that in order to achieve quality classroom teaching, the solutions should start from teachers.

According to Kennedy (2001):

It is true that we want and need a “quality profession”. Yet it is equally true that we need individual teachers who make up the profession to be committed to quality teaching.....what the profession says as a whole should come to life in individual classroom (p. 6).

One major way to improve mathematics instruction and learning is to help teachers understand students’ Mathematics thought processes (Fennema, Carpenter, Franke, Levi, Jacobs & Empson, (1996). Knowledge of students’ cognition is seen as one of the important components of teacher knowledge, because according to Fennema and Franke (1992), learning is based on what happens in the classroom

Ghanaian education researchers have also carried out research studies to reveal some of the difficulties pupils face learning Mathematics by looking at teachers' content knowledge and pedagogical knowledge (Davis & Ampiah (2008); Asiedu-Addo & Yidana, 2000). However, no study in Ghana has particularly looked at pre-service teachers' pedagogical content knowledge in order to ascertain pre-service teachers' knowledge of students' thinking processes, how they give reasons for students' misconception and how they ask questions to diagnose students' misconceptions.

According to Ball (2000), when preparing pre-service teachers it is necessary to identify the important content knowledge needed for teaching, how that knowledge is to be understood, and how that knowledge is used in the classroom. Shulman (1986) believed that teachers need knowledge more than just knowledge of their content area and generalized knowledge of pedagogy to be a good teacher. Also, teachers needed the ways of presenting and formulating the subject that make it comprehensible (Shulman, 1986) as well as what make the concept easy and difficult for others and possible misconceptions that students may have. Graeber (1999) identified that understanding students' common misconceptions, using effective strategies to help students avoid them, was an important aspect of mathematical PCK. In addition, Turnuklu and Yesildere (2007) studied pre-service teachers' PCK in Mathematics and revealed that having a deep understanding of Mathematical knowledge is necessary but not sufficient to teach Mathematics. Therefore, pre-service teachers should be educated both from Mathematics knowledge and pedagogical content knowledge.

Meanwhile, Marshman and Porter (2013) studied pre-service teachers' knowledge of students' thinking on addition of fractions and found out that only two (2) pre-service teachers (out of 42 responses) identified students' misconception. Besides, majority of the pre-service teachers were not able to provide appropriate feedback since they could not diagnose students' misconceptions. Furthermore, Jones and Moreland (2004) explored the frameworks and cognitive tools that have been developed to enhance pre-service teachers' pedagogical content knowledge and found out that the pre-service teachers were able to identify the students' misconceptions but could not give the reasons for the students' misconception.

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Also Grouws and Schultz (1996) studied pre-service teachers' PCK and found out that pre-service teachers were not aware of students' reasoning which was responsible for their misconceptions.

Since teachers were not aware of students' reasoning, their teaching was not based on existing mathematical misconceptions of the students. An, Kulm and Wu (2004) compared pre-service teachers' pedagogical content knowledge in Mathematics. They observed that teachers could identify students' misconceptions but have difficulty in determining the reasons for the misconceptions in addition of fractions and decimal fractions. Similarly, Stacey, Helme, Steinle, Baturu, Irwin and Bana (2001) investigated pre-service elementary school teachers' content knowledge and pedagogical content knowledge. Results pointed to the need for teacher education to emphasize content knowledge that integrates different aspects of number knowledge, and pedagogical content knowledge that includes a thorough understanding of student common difficulties

Theoretical Framework

The study was based on Shulman's (1986) Transformative theory of pedagogical content knowledge (PCK) — *knowledge of content and students thinking processes (KCS)*. Shulman identified that discipline knowledge alone is insufficient for successful teaching. According to Shulman (1986) teachers need a special knowledge of students' thinking to understand typical student conceptions and misconception, and why these misconceptions. For that matter, Shulman presented a strong case for pedagogical content knowledge (PCK) as a specific form of knowledge for teaching which allows teachers to understand and anticipate particular preconceptions or learning difficulties of their students.

Statement of the Problem

The World Bank (2007) thematic study report on Developing Science, Mathematics, and Information Communication Technology Education in Sub-Saharan Africa (SMICT) with Ghana among the ten countries selected, indicated that during pre-service teacher training, pedagogical content knowledge was not dealt with adequately. As a result, pre-service teachers did not have sufficient confidence in their ability to deal with matters if something went wrong during lessons. As a result many students do not succeed and are then stuck with misconceptions. Besides, there is little direct information about the PCK and teacher-centered methodology coupled with lack of awareness and knowledge as to how to address students' conceptual errors, leads to superficial learning based on recall and not on comprehension.

Meanwhile, Mathematics concepts are counter-intuitive; therefore, pre-service teachers need to be aware of where and when students are prone to make mistakes so that they can diagnose students' misconceptions with an extensive repertoire of remedial techniques, which need to be very specific for the concepts and subject (Ottevanger et al, 2007). During teaching practice supervision, in the usual clusters of Akatsi District, it was observed that pre-service teachers could not deal with pupils' errors and mistakes well. A major factor could be that the pre-service teachers lacked pedagogical content knowledge. The study intended to investigate pre-service teachers' use of pedagogical content knowledge in teaching and learning of Mathematics (fractions) at Basic seven (7) in the Akatsi District of Ghana.

Purpose of the study

The purpose of the study was to explore how pre-service teachers use their pedagogical content knowledge to identify pupils' misconceptions, give reasons for pupils' misconceptions and ask specific questions to diagnose pupils' misconceptions in the teaching and learning of fractions in Mathematics.

Research Questions

The study intended to answer the following questions:

- 1) How do pre-service teachers' use their pedagogical content knowledge to identify students' misconceptions in the teaching and learning of fractions?
- 2) To what extent can pre-service teachers give reasons for students' misconceptions in the teaching and learning of fractions?

3) How do pre-service teachers use their pedagogical content knowledge skills to ask questions in order to diagnose students' misconceptions in the teaching and learning of fractions?

METHODOLOGY

Research Design

The research made use of descriptive survey. This type of research would assist to describe the characteristics that exist in population, but not to determine the cause-and- effect relationship. The justification for the use of the design was that it provided detailed description of the PCK of pre-service Mathematics teachers and how these translated into the teaching and learning of fractions.

Population

The population of the study was 320 pre-service teachers of Akatsi College of Education (2014/2015 academic year) who taught Mathematics during their teaching practice in the cluster of schools located in the Akatsi District of the Volta Region of Ghana.

Sample and Sampling Procedure

Seventy-two (72) pre-service teachers teaching Mathematics at Basic 7 were purposively selected for the study. This was because the content under consideration (comparison, addition, multiplication and division of fractions) was found in the Basic 7 Mathematics curriculum. Also, the teaching and learning of these topics terminated at Basic 7 before the students write their Basic Education Certificate Examination.

Instrument

The instrument used for the study was questionnaire. Some items in the questionnaire on the misconceptions of multiplication, addition and division of fractions were adapted from a similar study conducted by Turnuklu and Yesildere (2007) and Chick and Baker (2005). The item on comparison of fraction was self-developed. The questionnaire was structured with open ended items. The complete questionnaire was given to the team of supervisors in the field of Mathematics education for expert judgment in order to ensure content validity and item relevance. The

questionnaire-approach was suitable because it allowed teachers to make considered responses to the questionnaire without feeling pressured to answer on the spot.

The questions adapted from Turnuklu and Yesildere (2007) and Chick and Baker (2005) were used to construct four in- class problems. The four in- class problems were designed to investigate the use of teachers' PCK on identifying students' misconception, giving reasons for students' misconceptions, and asking specific questions, to diagnose students' thinking processes.

Data Collection Procedure

The researchers administered the questionnaires to seventy-two (72) pre-service teachers who returned from their teaching practice to write their final examinations. Discussions were held with the pre-service teachers who taught Basic 7 before the questionnaires were administered to them. There were twelve (12) items on teachers' PCK in the questionnaire which were sub-divided into

three thematic areas namely identification of students' misconception, giving reason(s) for students' misconception and diagnosing students' misconception through specific questioning.

Data Analysis

Data were analyzed using means. The frequencies were converted into percentages for each criterion and were used for the analysis. Data collected from teachers were examined based on the criteria set according to the components of pedagogical content knowledge. The criteria for each problem were listed below:

- a) Identifying students' misconception.
- b) Giving appropriate reason(s) for students' misconception.
- c) Asking specific questions to diagnose students' misconception.

In the analyses, three (3) points were given for correct identification of students' misconceptions, correct reasons for the misconception, and asking specific questions (what the student did wrong), to diagnose students' misconception. Two (2) points for correct identification of students' misconceptions, giving insufficient reasons of students' misconceptions and asking probing questions (questions directing students to clarify what they are trying to say to improve a disorganized answer or one that is partly right) instead of specific questions to diagnose students' misconceptions and one (1) point was given for non-identification of students' misconception, giving no reasons for the misconception, and asking unclear questions (ambiguous questions) to diagnose students' misconceptions. Also, a grand mean between 2.45 – 3.00 were determined as excellent, grand mean between 1.95 – 2.44 as moderate and grand mean between 1.00 – 1.94 as insufficient pedagogical content knowledge. Pre-service teachers' grand mean scores were calculated for assessing their performance on all 4 problems combined and they were interpreted according to the three (3) criteria listed above.

RESULTS

Research question 1: How do pre-service teachers' use their pedagogical content knowledge to identify students' misconceptions in the teaching and learning of fractions?

Table 1: Percentages of Teachers' responses according to identification of Students' misconceptions

Nature of Error	1 point f_1 (%)	x_1	3 point f_2 (%)	x_2	\bar{x}
Solution $\frac{1}{4} > \frac{1}{3}$					
Identification of students' misconception	31(43.1%)	31	41 (75%)	123	2.14
Solution $\frac{7}{10} + \frac{2}{5} = \frac{7}{10} + \frac{4}{10} = \frac{11}{20}$					
Identification of students' misconception	38 (52.8%)	38	34(47.2%)	102	1.92
Solution $\frac{1}{4} \times \frac{1}{5} = \frac{5}{20} \times \frac{4}{20}$					
Identification of students' misconception	22(30.6%)	22	50(69.4%)	150	2.39
Solution $\frac{9}{10} \div \frac{3}{10} = \frac{10}{9} \times \frac{3}{10}$					
Identification of students' misconception	33(45.8%)	33	39(55%)	117	2.08
Grand Mean	43.08%		56.93%		2.13

Where f_i is the number of respondents, $x_i = point \times f$ (the score for number of respondent) and

$$\bar{x} = \frac{x_1 + x_2}{72}.$$

Table 1 indicated that a large number of pre-service teachers (Mean = 56.9%) were able to identify students' misconceptions. This showed that most of the pre-service teachers were aware of students' misconceptions when carrying out operation on fractions. A grand mean of (2.13) indicated that on the average the pre-service teachers have moderate pedagogical content knowledge on identification of students' misconceptions.

Research question 2: To what extent can pre-service teachers give reasons for students' misconceptions in the teaching and learning of fractions?

Table 2: Percentages of Teachers' responses according to Teachers' knowledge of reasons for Students' Misconceptions

Nature of Error	1 point		2 point		3 point		\bar{x}
	f_1 (%)	x_1	f_2 (%)	x_2	f_3 (%)	x_3	
Solution $\frac{1}{4} > \frac{1}{3}$							
Giving appropriate reason(s) of students' misconception	40(55.6%)	40	20 (27.8%)	40	12(16.7%)	36	1.60
Solution $\frac{7}{10} + \frac{2}{5} = \frac{7}{10} + \frac{4}{10} = \frac{11}{10}$							
Giving appropriate reason(s) of students' misconception	45(62.5%)	45	14(19.4%)	28	13 (18.1%)	39	1.60
Solution $\frac{1}{4} \times \frac{1}{5} = \frac{5}{20} \times \frac{4}{20}$							
Giving appropriate reason(s) of students' misconception	42 (58.3%)	42	18(25%)	36	12(16.7%)	36	1.60
Solution $\frac{9}{10} \div \frac{3}{10} = \frac{10}{9} \times \frac{3}{10}$							
Giving appropriate reason(s) of students' misconception	26 (63.9%)	46	14(19.4%)	28	12 (16.7%)	36	1.50
Grand Mean	60.08%		22.90%		17.05%		1.58

Where f_i is the number of respondents, $x_i = point \times f$ (the score for number of respondent) and $\bar{x} = \frac{x_1+x_2+x_3}{72}$.

Table 2 showed that 17.1% of the pre-service teachers could not give reasons for pupils' misconceptions. Meanwhile, 60.1 % of the teachers were able to give sufficient reasons for pupils' misconceptions. However, 22.9% gave insufficient reasons for pupils' misconceptions. Even though from table 1, on a scale of zero (0) to 100, a little above average (Mean = 56.93%) pre-service teachers were able to identify students' misconceptions, it was evident from table 2 that greater proportion, 82.98% (60.08% + 22.90%) of the pre-service teachers were not able to give reasons to support the reasons why students showed those incorrect thought processes. A grand mean of (1.58) revealed that on the average the pre-service teachers have insufficient pedagogical content knowledge on giving appropriate reason(s) for students' misconceptions.

Research question 3: How do pre-service teachers use their pedagogical content knowledge skills to ask questions in order to diagnose students' misconceptions in the teaching and learning of fractions?

Table 3: Percentages of Teachers' responses according to Questions Teachers ask to diagnose Students' Misconceptions

Nature of Error	1 point		2 point		3 point		\bar{x}
	f_1 (%)	x_1	f_2 (%)	x_2	f_3 (%)	x_3	
Solution $\frac{1}{4} > \frac{1}{3}$							
Asking appropriate questions to diagnose students' misconception	26(36.1%)	26	42(58.3%)	84	4(5.5%)	12	1.60
Solution $\frac{7}{10} + \frac{2}{5} = \frac{7}{10} + \frac{4}{10} = \frac{11}{20}$							
Asking appropriate questions to diagnose students' misconception	21(29.2%)	21	41(56.9%)	82	10(13.9%)	30	1.85
Solution $\frac{1}{4} \times \frac{1}{5} = \frac{5}{20} \times \frac{4}{20}$							
Asking appropriate questions to diagnose students' misconception	22(30.6%)	22	40(55.6%)	80	10 (13.9%)	30	1.83
Solution $\frac{9}{10} \div \frac{3}{10} = \frac{10}{9} \times \frac{3}{10}$							
Asking appropriate questions to diagnose students' misconception	13(18.1%)	13	43(59.7%)	86	16(22.2%)	48	2.04
Grand Mean	28.5%		57.63%		13.88%		1.83

Where f_i is the number of respondents, $x_i = point \times f$ (the score for number of respondent) and $\bar{x} = \frac{x_1+x_2+x_3}{72}$

Table 3 indicated that a large number of pre-service teachers (Mean = 57.63 %) asked probing questions, (questions directing students to clarify what they are trying to say to improve a disorganized answer or one that is partly right) . Indeed, probing questions could not enable pre-service teachers to ascertain what actually went wrong during the students' thought processes unlike specific question. Only a smaller number (Mean =13.88%) asked specific questions to reveal the students' thinking process that lead to the misconceptions. This assertion was supported by the evidence in table two which revealed that 82.98% (60.08% + 22.90%) of the pre-service teachers could not give reasons to support why students exhibited those incorrect thought processes. A grand mean of (1.83) showed that on the average the pre-service teachers have insufficient pedagogical content knowledge on asking specific questions to diagnose students' misconceptions.

DISCUSSION

The results in Table 1 and Table 2 showed that pre-service teachers were able to identify students' misconceptions but could not articulate the reasons for the misconceptions. The finding was consistent with the studies conducted by Jones and Moreland (2004) who found out that the pre-service teachers were able to identify the students' misconceptions but could not give the reasons for the students' misconception. An, Kulm and Wu (2004) also compared pre-service teachers' pedagogical content knowledge in Mathematics. They observed that teachers could identify students' misconceptions but had difficulty in determining the reasons for the misconceptions. However, our finding on identification of students' misconception was in sharp contrast with the study conducted by Marshman and Porter (2013) who studied pre-service teachers' knowledge of students' thinking on addition of fractions and found out that only two (2) pre-service teachers out of 42 identified students' misconception.

Also the result from table 2 revealed that pre-service teachers could not give reasons for students' misconception. This finding is in line with the study conducted by Grouws and Schultz (1996) on pre-service teachers' PCK which revealed that pre-service teachers were not aware of students' reasoning which was responsible for their misconceptions. Since teachers were not aware of students' reasoning, their teaching was not based on existing mathematical misconceptions of the students

The results in Table 3 also pointed out that majority of the pre-service teachers could not ask specific questions to diagnose students' misconceptions. This finding gave credence to the study conducted by Marshman and Porter (2013) who studied pre-service teachers' knowledge of students' thinking on addition of fractions and found out that majority of the pre-service teachers were not able to diagnose students' misconceptions hence, could not provide appropriate feedback.

CONCLUSIONS

Based on the findings and discussions that followed, it can be concluded that:

1. Most pre-service teachers were able to identify students' misconception.
2. Majority of the pre-service teachers could not give reasons for the students' misconceptions.
3. Majority of the pre-service teachers could not ask specific questions to diagnose students' misconceptions.

RECOMMENDATIONS

Based on the discussion and conclusions, it was recommended that;

1. Teacher training institutions could integrate pedagogical content knowledge (teachers' knowledge of students' thinking) courses which would equip teacher trainees with skills to analyze students' thinking processes.

2. Ministry of Education in collaboration with Institute of Education, University of Cape Coast incorporates the concepts of pedagogical content knowledge into the Mathematics curriculum to enable pre-service teachers to be equipped with the skills of analyzing students' thinking processes.

REFERENCE

- An, S., Kulm, G. & Wu, Z. (2004). The pedagogical content knowledge of middle school, Mathematics teachers in China and the U.S., *Journal of Mathematics Teacher Education* 7, 145–172.
- Asiedu.-Addo, S.K., & Yidana, I. (2000). Mathematics teachers' knowledge of the subject content knowledge and methodology. *Journal of the Mathematical Association of Ghana*, 12, 63-71.
- Ball, D.L., Thames, M.H., & Phleps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, 59, 398-407.
- Ball, D. L. (2000). Bridging practices: Intertwining content and pedagogy in teaching and learning to teach. *Journal of Teacher Education*, 51, 241-247.
- Battey, D., Chan, A. G., Franke, M. L., & Webb, N. M. (2009).Teacher questioning to elicit students' mathematical thinking in elementary school classroom. *Journal for Research in Mathematics*, 34, 94-116.
- Carpenter, T., Fennema, E., Peterson, P.L., & Carey, D. (1998). Teacher's pedagogical content knowledge of students' problem solving in elementary arithmetic. *Journal for Research in Mathematics Education*, 19, 385-401.

- Chick, H. L., & Baker, M. (2005). Investigating teachers' responses to student misconception. In H. L. Chick & J. L. Vincent (Eds.). *Proceeding of the 29th annual conference of the PME. International Group for the Psychology of Education*, 2, 249-256.
- Cochran, K.F., DeRuiter, J.A., & King, R.A. (1993). Pedagogical content knowing: An integrative model for teacher preparation. *Journal of Teacher Education*, 4, 263-272.
- Darling-Hammond, L. (2006). Constructing 21st - Century teacher education. *Journal of Teacher Education*, 57, 300-312.
- Darling-Hammond, L. (2010). Recruiting and retaining teachers: Turning around the race to the bottom in high-need schools. *Journal of Curriculum and Instruction*, 4, 16-32.
- Davis, E.K., & Ampiah, J.G. (2008). The impact of in-service teacher training through Outreach Program on pedagogical skills and attitudes of basic school teachers in the central region of Ghana. *Ghana Journal of Education and Teaching*, 1, 29-38.
- Feiman-Nemser, S. (2012). Beyond solo teaching. *Educational Leadership*, 69, 10- 6
- Fennema, E., & Franke, M. L. (1992). Teachers' knowledge and impact. In D.A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning*, (pp. 147-164). New York: Macmillan.
- Fennema, E., Carpenter, T. P., Franke, M. L., Levi, L., Jacobs, V. R. & Empson, S. B. (1996). A longitudinal study of learning to use children's thinking in mathematics instruction. *Journal for Research in Mathematics Education*, 27, 16-32.
- Gearheart, M., & Saxe, G.B. (2004). When teachers know what student know: Integrating Mathematics assessment. *Theory into Practice*, 43, 304-313.

Graeber, A. O. (1999). Forms of knowing mathematics: What pre-service teachers should learn. *Educational Studies in Mathematics*, 38, 189-208.

Grouws, D., & Schultz, K. (1996). Mathematics teacher education in: J. Sikula (Ed) *Handbook of Research on Teacher Education*, 2nd edition (USA: Macmillan).

Jones, A., & Moreland, J. (2004). Enhancing practicing primary school teachers' pedagogical content knowledge in technology, *International Journal of Technology and Design Education* 14, 121-140.

Kennedy, K. (2001). *Beyond the rhetoric: Building a teaching profession to support quality teaching*. Canberra: Australian College of Education.

Langrall, C., Thornton, C., Jones, G., & Malone, J. (1996). Enhanced pedagogical knowledge and reflective analyses in elementary mathematics teacher education, *Journal of Teacher Education*, 47 (4), 271-281.

Lockheed M. E, Verspoor, M. A (1991). *Improving primary education in developing countries*. Oxford; Oxford University Press.

Marshman, M., & Porter, G. (2013). Pre- Service Teachers' Pedagogical Content Knowledge: Implication for Teaching. Retrieved January 15, 2016 from http://www.merga.net.au/documents/Marshman_et_al_MERGA36-2013.pdf

Ministry of education (1996). *Basic education sector improvement programme policy document*, Accra, Ghana.

Ottevanger, W., Van den Akker, J.J.H., & De Feiter, L. (2007). Developing science, Mathematics and ICT education in Sub-Saharan Africa (SMICT): Patterns and promising practices, *World Bank working paper, 101*, 1-84.

Panesar, S. (2010). Exploring disparities between teachers' expectations and the realities of the education profession. *Research in Higher Education Journal*, 8, 1-19.

Pecku, M. (1998). Teacher education in Ghana: Evaluations and prospects. Accra: Elorm Electronics and Business Service.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15, 4-14.

Stacey, K., Helme, S., Steinle, V., Baturo, A., Irwin, K., & Bana, J. (2001). Pre-service teachers' knowledge of difficulties in decimal numeration, *Journal of Mathematics Teacher Education*, 4, 205-225.

Turnuklu, E. B., & Yesildere, S. (2007). *The pedagogical content knowledge in mathematics*. Retrieved January 10, 2016 from <http://www.k-12prep.math.ttu.edu>.

World Bank. (2007). *Developing science, mathematics and ICT education in Sub-Saharan Africa (SMICT)*. Retrieved January 5, 2016 from http://siteresources.worldbank.org/INTAFRREGTOPSEIA/Resources/them_VUA_SMICT.pdf