Original Research Article

The Impact of Professional Development on The Pedagogical Content Knowledge of The Mathematics Teacher

ABSTRACT

Aim: The study Sought to explore the impact of professional development on the pedagogical content knowledge of the mathematics teacher in Ghana.

Study Design: The study used a case study research design.

Methodology: Three research instruments, namely; documents, interview and semi-structured open-ended questionnaires was used for the study. Twelve (12) teachers were sampled from a teacher population of forty-eight (48) mathematics teachers from nine (9) government assisted Senior High Schools in the Keta Municipality to respond to the questionnaire, while a Deputy Director of Education was interviewed to gather qualitative data for analysis.

Results: This research study identified that professional development had positive impacts on the Pedagogical Content Knowledge of mathematics teachers.

These findings imply that, professional development for teachers is important to ensure effective teaching for improved performance of students in mathematics.

Conclusions: Teachers were of the view that they should be included in the planning process of the professional development programmes, realistic duration for the programmes, they also suggested

teacher motivation for participation, called for consistency in the organization of the programmes, follow-up programmes and also provision of adequate learning materials.

Keywords: mathematics; professional development; pedagogical content knowledge; technology

1.INTRODUCTION

Research works as they appear in literature, show a lack of consensus among scholars on a working definition for mathematics teacher professional development (Bredeson 2002). For Bredeson, there's a plethora of terms such as continuing education, in-service training, staff development and self-improvement that are used interchangeably with the term professional development with little regard for any conceptual and practical differences. Avalos (2010), explained that this may happen as the concept of mathematics teachers' professional development can be viewed from several different perspectives, each with its own conceptual premise and is informed by different bodies of research and their orientations.

Despite the apparent lack of consensus, most of the literature described mathematics teacher professional development as an intentional, ongoing and systematic process of formal and informal education, training, learning and support activities that take place in either external or work-place settings and proactively engaged in by teachers, school principals and other school leaders with others which have direct or indirect benefit to the individual teacher, the school and also the nation (Bolam, 2002).

According to Avalos (2010), teacher professional development is about teachers learning, learning how to learn, and transforming their knowledge into practice for the benefit of their students' growth. Professional development in this sense can be described as the process of accumulating skills, professional knowledge, values and personal qualities that enables teachers to continually adapt within the educational system.

Professional development has gained grounds in Ghana over the past decades and has therefore become an essential subject of discourse due to its significance in the area of mathematics education (Asante, 2012). Professional development in our part of the world takes several forms, in-service training

programs like workshops and seminars organized by the government and also by private individuals and organizations, distance courses, sandwich and regular courses, professional meetings, case conferences, qualification programmes, observation visits to other schools, mentoring, amongst others. The Ghana National Association of Teachers (GNAT) collaborates with the Canadian Teachers Federation (CTF) to organize In-Service Courses for teachers in; Educational Administration for Heads of Basic Schools, Senior High School Mathematics, Senior High School English Language, Junior High School English Language, Junior High School Social Studies, Junior High School Mathematics, Junior High School Science , Junior High School French, Junior High School Basic Design and Technology, Primary Mathematics and Science, Special Class for Female Basic School Teachers of Science and Mathematics - a collaboration which started in the country five decades ago.

The 2014 GNAT- CTF organized professional development workshop was designed to upgrade the capacity of teachers at basic and second cycle institutions in the Ashanti Region with two hundred and seventy teachers from both basic and second cycle schools in the region, made up of 160 males and 110 females, participated.

The Ghana Investment Fund for Electronic Communication (GIFEC) is a project aimed at organizing managerial training for ICT teachers in second cycle institutions and providing computers, scanners and projectors to the schools for which every teacher including mathematics teachers' use as teaching aid. The better Ghana Agenda (free laptop project by the government of Ghana) was aimed at providing free laptops to teachers and students, the District/Municipal/Metropolitan Directorates of the Ghana Education Service organize periodic workshops and in-service training programs for teachers to ensure professional development, a nationwide workshop on Integrating ICT into the Teaching of Science, Mathematics and English was organized by the Ghana Education Service (GES) in May, 2013 for Science, Mathematics and English teachers.

In 2013, 600 teachers from the Upper East, Upper West, Northern and Brong-Ahafo regions benefited from the GNAT-CTF collaboration, among the subjects tackled during the five-day workshop were English, Mathematics and Science for basic and senior high school teachers; special skills training

program in Mathematics and Science for female teachers and Basic Design and Technology, French, Education Administration for basic school heads and heads of second cycle institutions. The Taft Education Workshops for teachers among others are a few examples of teacher professional development programmes in Ghana.

The Volta Regional branch of GNAT has a vision of promoting the professional development of its member teachers. The association has 17,700 teachers at the basic, Secondary and Colleges of Education as members, as at 23rd January 2014. The Association promotes professionalism and ensures high academic standards among its members by regularly upgrading their skills and knowledge to ensure that they are abreast of modern trends in the teaching profession across the world in providing holistic education. The association put up a hostel facility at the regional capital Ho, to provide accommodation for teachers who travel to the capital to participate in in-service training and weekend courses organized by GNAT. Also, GNAT collaborates with the CTF to organize various upgrade courses for teachers in the region amongst others. All in anticipation of promoting teacher professionalism and efficiency, which would in turn result in good academic performance of students.

The performance of students in mathematics in the West African Examination Council (WAEC) examinations besides all the efforts by government, civil society, teacher associations, the teachers themselves and so on, to improve performance leaves much to be desired. In 2003, Ghana for the first time participated in Trends in International Mathematics and Science Study (TIMSS) in order to find out the performance of her students in science and mathematics compared with those of other countries, Ghana's overall performance in mathematics was very poor, placing it in the 45th position, the overall score of 276 was far below the international mean of 467. According to the Trends in International Mathematics and Science Study (TIMSS, 2007) reports, the overall performance of Ghanaian students who participated was again poor. Out of fifty participating countries, Ghana ranked 47th. According to the report, there was a large variation in mathematical abilities among the students with some scoring as low as 162 and others scoring as high as 461. The overall average scale score of 309 obtained was far below the international mean of 500. The Ghanaian students' average percent correct on all items out of the

236 score points was 18 score points with a standard error of 0.4. It is interesting to know that Ghana's score was lower than those obtained by all the five participating African countries.

A report in The Ghanaian Times News Paper on March 19, 2013, indicated that18% of 2012 West African Senior School Certificate Examination (WASSCE) candidates failed in mathematics. According to the report, about 31,389 students, representing 18 per cent, of the 174,385 candidates who sat for the 2012 WASSCE, failed in Mathematics. This was revealed by the WAEC at the 2013 WAEC National Excellence Awards, where nine students, were honored for their excellent performance in the 2012 WASSCE. Studying the West African Examination Council (WAEC) Chief Examiners' Report over the years, the general comments on the performance of senior high students in mathematics has consistently been poor performance. It is mind boggling to know the kind of words used in the report to describe the performance of students in the West African Senior School Certificate Examination (WASSCE) Core Mathematics over the years. Chief Examiners' Report (2008), general comments on performance in core mathematics "the performance of candidates was quite poor" (p. 7). Chief Examiners' Report (2009), general comments on performance in core mathematics "the performance of candidates was not as encouraging in spite of the fact that questions were within the scope of the syllabus" (p. 25). Chief Examiners' Report (2011), general comments on performance in core mathematics "the performance of candidates was not encouraging" (p. 169). Chief Examiners' Report (2012), general comment on performance in core mathematics "the performance of candidates was satisfactory" (p. 422).

Several factors contribute to the poor performance of students in mathematics. According to Mbugua, Kibet, Muthaa and Nkonke (2012), factors that contribute to the poor performance of students in mathematics includes student factors such as entry behavior, motivation and attitude, socio-economic factors such as education of parents and their economic status, school-based factors such as availability and usage of teaching/learning facilities, school type and teacher characteristics. Teacher characteristics according to Perrott (1982), includes: "teacher enthusiasm, orientation, clarity, and ability to deliver; selection and sequencing of each task to match the cognitive experiences of learners; and variation of teaching methods and materials" (p.86). There are two categories of people in the mathematics classroom, both of them play very vital roles in the teaching and learning process (Asante, 2012). The

poor performance of students in mathematics is attributed to the attitude of students towards mathematics, gender differences and several other factors including the teacher factor (Casey, Nuttall, & Pezaris, 2001). There is therefore the need to conduct a research into the professional development of teachers and its' impact on their pedagogical content knowledge.

1.1 Purpose of the Study

The purpose of this study was to explore the impact of professional development on the pedagogical content knowledge of the mathematics teacher, and how it could improve the performance of students in the Keta municipality.

1.2 Research Questions

The following research questions guided the study:

1. What impacts does professional development have on the pedagogical content knowledge of mathematics teachers in the Keta municipality?
2. How could professional development programmes improve teacher efficacy and students' performance in mathematics?

2.LITERATURE REVIEW

2.1 Theoretical framework

The theoretical framework of the study is based on two related theories: the constructivist theory and the theory of adult education. A review of literature indicates that professional development is informed by these two sets of theories.

2.1.1 Constructivism

The constructivist theory is based on the premise that we all construct our own perspective of the world through individual experiences and schema. The constructivist looks at the learner as more than just an active processor of information (Pritchard, 2010). The learner creates his/her own meaning of knowledge. Therefore, the goal of instruction is not to know particular facts, but to interpret and elaborate on information. The constructivist theoretical framework provides a grounds for the understanding of how human beings integrate new knowledge into existing cognitive structures and then make sense out of that knowledge (Ferguson, 2007).

Constructivism perceives that, people construct their own concepts, understanding and knowledge of the environment by abstracting their experiences (Prawat & Floden, 1994; Hein, 1991). Focusing on the application of the constructivist approaches in classroom instruction, Perkins (1999) thinks, "the stimuli that we encounter, including messages from others, are never logically sufficient to convey meaning. To some extent, the individual always has to construct or reconstruct what things mean. It thus makes sense to organize learning to reflect this reality" (p. 8). For Hoover (1996), as learners' understanding of the environment will be challenged continuously by new experiences, they are likely to adjust their understanding to accommodate new experiences especially if they find out that their current knowledge is inconsistent or not relevant to current trends. Daley (2003) found in a study of the professional practice of 18 elementary, middle and high school teachers in the US, that teachers' knowledge bases were changed each time they experienced something new. According to her, the new information learned in professional development programmes was added to a teacher's knowledge base through a complex process of thinking about the new information, acting on the new information, and identifying their feelings about the information. This suggests that teacher

professional development is a process that supports teachers to construct and reconstruct new knowledge of teaching practice rather than to receive knowledge passively (Murphy, 1997).

In the discussion of elements affecting the practice of teaching mathematics in the UK, Ernest (1989) argued that teachers' mental models of teaching and learning mathematics affected their practice. Spillane and Louis (2002), outlined in a discussion of school improvement in the US that knowledge of instruction is generated by teachers inside classrooms and argued, "Efforts to improve instruction - policy, school reform initiatives, and professional development are filtered through teachers' personal beliefs, knowledge and extant instructional practices" (p.91). Teachers are unlikely to import and use instructional knowledge without personal adjustment. Helping teachers to continuously build their knowledge base from experiences and to refine or change their own philosophy of teaching is likely to improve their future teaching practice (Holloway, 1999; Hoover, 1996).

2.1.2 Adult learning

Adult learning is a type of teacher professional development (Peredo, 2000; Wood & Thompson, 1993). According to a report on quality teaching in the US, the Education Commission (2000), recommended that policymakers and educators should become familiar with the elements of adult learning that made professional development of teachers effective. It takes a high level of maturity to be able to learn on one's own, self-directed learning is a foundation of adult learning (Merriam, 2001). Brookfield (1995), sees self-directed learning as "the process by which adults take control of their own learning, in particular how they set their own learning goals, locate appropriate resources, decide on which learning methods to use and evaluate their progress" (p.375). Adults are usually self-directed learners (Brookfield, 1995; Merriam & Caffarella, 1991;

Brookfield, 1986). They often perceive themselves as being responsible for their own decisions (Knowles, 1990).

Literature reveals that adult learning is usually experiential and problem-based (Tight, 2002; Brookfield, 1986). It is more likely to be based on personal experience (Wood & Thompson, 1993). Adult learners carry their craft knowledge into learning, when learning is contextualised and connected to their craft knowledge, they are likely to be more engaged and gain more from the learning experiences.

2.2 Teacher Professional Development

Professional development in a general sense refers to the development of a person in his/her professional role (Avalos, 2010). Teacher professional development according to Glatthorn (1995) "is the professional growth a teacher achieves as a result of gaining increased experience and examining his/her teaching systematically" (p.41). Ganser (2000) considers PD as including formal experiences such as attending workshops and professional meetings, mentoring etc. and informal experiences such as reading professional publications, watching television documentaries related to the academic discipline etc. obviously this conception of PD is broader than career development, which is defined by Glatthorn (1995) as "the growth that occurs as the teacher moves through the career cycle" (p.41) and much broader than staff development which is "the provision of organized in-service programmes designed to foster the growth of a group of teachers; it is only one of the systematic interventions that can be used for teacher development " (Glatthorn, 1995, p.41). It is fair to conclude that TPD includes all the trainings a teacher receives either in a group or individually, organized by an individual, a group of teachers, an institution, teacher associations or the government, formally or informally whiles on the job.

2.3 Pedagogical Content Knowledge

Pedagogical content knowledge is an amalgam of content knowledge and pedagogical knowledge that underlie the understanding teachers' need to promote students' comprehension, a knowledge unique to the teaching profession (Shulman, 1987). According to Shulman, pedagogical content knowledge represents the best knowledge base for teaching, "The key of distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students" (p. 15).

Scholars have elaborated on Shulman's theory by proposing diverse conceptualizations of the features included or integrated within pedagogical content knowledge (Grossman, 1990; Loughran, Milroy, Berry, Gunstone, & Mulhall, 2001; Magnusson, Krajcik & Borko, 1999). For instance, Segall (2004), contended pedagogy cannot be considered simply a method, but rather pedagogy and content become one. According to her, conceiving of content and pedagogy as one, opens the possibility for educators and teacher educators to examine not only how people and issues are represented in subject-area texts but also how audiences are constructed and constituted as they are invited, pedagogically, to interact with those texts. Segall's research is relevant because she suggested additional research is needed in the examination of the influences on a teachers' development of pedagogical content knowledge.

Grossman's (1990) outlined four central components of pedagogical content knowledge.

1. conceptions of purposes for teaching subject matter (i.e., forming goals)

2. knowledge of students' understandings, conceptions, and misconceptions of particular topics in a subject matter
3. curricular knowledge
4. knowledge of instructional strategies and representations for teaching particular topics.

She acknowledged that "these components are less distinct in practice than in theory" (p. 9), but her general framework is useful for considering the ways in which the teachers develop their pedagogical content knowledge.

2.4 The Impact of Teacher Professional Development

In a fast changing and developing world like ours, the surviving mathematics teacher is one who constantly develop him/herself to be able to stand the test of time. Consequently, whether formal or informal, professional development has been proven in literature to be a formidable force behind teachers' fight to be up to task. According to Smith and O'Day (1991), "professional development is considered an essential mechanism for deepening teachers' content knowledge and developing their teaching practices. As a result, professional development could be a cornerstone of systemic reform efforts designed to increase teachers' capacity to teach to high standards" (p. 81).

Lately, a large body of literature has emerged on in-service professional development, teacher learning, and its' impact on performance. There is an emerging professional consensus about particular characteristics of high-quality professional development. These characteristics include a focus on content and how students learn content, in-depth, active learning opportunities, links to high standards, opportunities for teachers to engage in leadership roles, extended duration and the collective participation of groups of teachers from the same school, form or department.

Although lists of characteristics such as these commonly appear in the literature on effective professional development, there is little direct evidence on the extent to which these characteristics are related to better teaching and increased student performance (Garet, Porter, Desimone, Birman, & Yoon, 2001; Loucks-Horsley, Hewson, Love & Stiles, 1998).

Studies conducted over the past decades on PD suggest that PD experiences that share all or most of these characteristics can impact positively on teacher efficacy and student performance (Birman, Desimone, Garet, & Porter, 2000; Garet, Porter, Desimone, Birman, & Yoon, 2001; Wilson & Lowenberg, 1991). In examining the characteristics of PD that have positive impacts, several studies have found that the intensity and duration of professional development is related to the degree of teacher change (Shields, Marsh, & Adelman, 1998; Weiss, Montgomery, Ridgway, & Bond 1998). There is some indication that compared to professional development focused on general pedagogy or classroom management strategies, professional development that focuses on specific mathematics content and the ways students learn such content is especially helpful, particularly for instruction designed to improve students' conceptual understanding (Fennema, Carpenter, Franke, Levi, Jacobs & Empson, 1996; Kennedy, 1998). Considering the magnitude of investment in professional development and the dependence of educational reforms on providing effective professional development, the knowledge base on what works must be strengthened so as to achieve intended results.

3. METHODOLOGY

This study used a case study design aimed at exploring from teachers' perspective, the impact of professional development on the pedagogical content knowledge of the mathematics teacher and how it

could improve the academic performance of students in the Keta municipality. Case study research, according to Merriam (1998) is an empirical enquiry that investigates a contemporary phenomenon within its' real-life context, especially when the boundaries between phenomenon and context are not clearly evident which results to an intensive, holistic description and analysis of a single instance, phenomenon or social unit. This approach was chosen as it allows vivid investigation of the phenomenon being studied (Ary, Jacobs, Razavieh & Sorensen, 2006).

The Deputy Director in charge of higher institutions was purposely selected for the interview. This sampling procedure was purposive because it was based on a personal judgment about specific needs that were typical to the study (Robson, 1995).

Subsequently, purposive sampling procedure was again utilized in the selection of participants for the questionnaire. In all, twelve (12) mathematics teachers completed the questionnaire in all the nine (9) schools.

The Teaching and Learning International Survey (TALIS) teacher questionnaire designed by the Organization for Economic Cooperation and Development (OECD) was adapted. The questionnaire was designed in three major sections; the first section which consisted of items 1- 4 sought for information about the background of participants. The second section consisted of items 5-13 which solicited for information on how professional development programmes are organized to attract mathematics teachers in the Keta municipality. The third section, which consisted of items 14-23 solicited for information from participants on the impact of professional development on the pedagogical content knowledge of mathematics teachers and how it could improve teacher efficacy and students' performance in mathematics in the Keta municipality.

4. RESULT

4.1 Research Question One

What impacts does professional development have on the pedagogical content knowledge of mathematics teachers in the Keta municipality?

The study revealed that professional development has a positive impact on the pedagogical content knowledge of mathematics teachers as follows;

- Improves formation of lesson goals
- Helps to identify individual learning capabilities in the classroom
- Keeping up with curricular reforms
- Helps teachers to be abreast with modern instructional strategies and approaches for teaching

4.2 Research Question Two

How could professional development programmes improve teacher efficacy and students' performance in mathematics?

The responses from the teachers suggests that professional development programmes highly improves teacher efficacy. Thus;

- Knowledge of instructional strategies and representations for teaching, helps teachers to adopt the best strategies of teaching for easy understanding of concepts
- Knowledge of the curricular materials aid's teachers in their preparation of lessons to promote; equity, inclusion and technology.
- Knowledge of the curriculum, helps to select content that is suitable for learners to enhance an inquiry driven learning environment.
- Being more knowledgeable of students' relevant previous knowledge of subject matter.

5.DISCUSSION

The study revealed that from the teachers' perspective, professional development has significant impacts on their pedagogical content knowledge. These findings are in line with the findings from the literature base reviewed (Porter, Garet, Yoon, & Birman , 2002; Shields, Marsh, & Adelman, 1998; Weiss, Montgomery, Ridgway, & Bond, 1998).

The participants indicated that as they participated in a variety of the professional development programmes, their orientations to the subject mathematics and their general philosophies of teaching mathematics keeps varying and they usually had to adapt varying strategies learnt to formulate lesson objectives that meets the specific needs of students whether individually, a group or as a class. This is supported by Putnam (1992), who claims that teacher beliefs and knowledge about teaching, learning, and content influence their decisions about what and how to teach more so than what is simply presented in curricular materials.

The participants admitted that their understanding of what mathematics students should learn has improved positively as it is influenced by their beliefs of the nature of mathematics. This is supported by Grossman (1990), who described teacher's conception of a subject for teaching as closely related to the teacher's beliefs about the nature of the subject itself.

6.CONCLUSION

This research study identified that professional development had positive impacts on the pedagogical content knowledge of mathematics teachers. These findings imply that, professional development for teachers is important to ensure effective teaching for improved performance of students in mathematics. In general, teachers' professional development is viewed as a platform for professional learning. As teachers participated in a variety of professional development programmes, their orientations to the subject mathematics and their general philosophies of teaching mathematics change and they learn

varying strategies to become more proficient in the formation of lesson goals for teaching their students (Putnam, 1992).

The finding further revealed that professional development has helped in introducing mathematics teachers to diversified approaches and modern trends to identifying and addressing the relevant previous understanding, conceptions, and misconceptions of students before introducing new concepts to them (Haller, 1997) and also provides the platform for teachers to interact with newly introduced teaching aid technologies to better their pedagogical content knowledge and improve their classroom teaching (Lloyd 1999). Professional development provides the best opportunities for teachers to broaden their curricular knowledge which contributes to the development of the pedagogical content knowledge of teachers (Haller, 1997).

Teacher professional development also provides the opportunity for teachers to be more informed of new and modern ways of formulating subject matter for instruction and representing subject matter for students to understand, which are the key components of pedagogical content knowledge (Shulman, 1986).

Consent

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

RECOMMENDATIONS

The following decisions or actions are therefore recommended in the study:

- Realistic duration for the programmes
- Teacher motivation for participation
- Consistency in the organization of the programmes
- Follow-up programmes and provision of adequate learning materials

- Decentralization of the professional development programmes: compulsory in-service training for newly recruited teachers and annual refresher courses for all teachers
- Involvement of classroom teachers in the planning of professional development programmes.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was funded by personal efforts of the authors.

REFERENCES

1. Ary, D., Jacobs, L. C., Razavieh, A., & Sorensen, C. (2006). *Introduction to research in education* (7th ed.). Belmont: Thomson Wadsworth.
2. Asante K. O. (2012). *Secondary students' attitudes towards mathematics*. Ife Psychology, Nigeria
3. Avalos, B. (2010). *Teacher professional development in teaching and teacher education over ten years*. Teaching and Teacher Education*,* 27, 10-20.
4. Birman, B., Desimone, Garet, M., & Porter, A. (2000). *Designing professional development that works*. Educational Leadership, 57(8), 28-33.
5. Bredeson, P. V. (2002). *The architecture of professional development: Materials, messages and meaning.* International Journal of Educational Research*, 37*(8), 661. doi: 10.1016/s0883-0355(03)00064-8.
6. Brookfield, S. D. (1986). *Understanding and facilitating adult learning: A comprehensive analysis of principles and effective practices.* Milton Keynes: Open University Press.

7. Brookfield, S. D. (1995). Adult learning: An overview [Electronic version]. In A. Tuinjman (Ed.), *International encyclopedia of education* (pp. 375-380). Tarrytown, NY: Pergamon. Retrieved from http//www.fsu.edu/~elps/ae/download/ade5385/Brookfield
8. Bolam, R. (2002). *Professional development and professionalism*. In T. Bush & R. Bell (Eds.), *The principles and practice of educational management* (pp. 103-118). London: Paul Chapman.
9. Casey, M.B., Nuttall, R.L., & Pezaris, E. (2001). *Spatial-mechanical reasoning skills versus mathematics self-confidence as mediators of gender differences on mathematics subtests using cross-national gender-based items.* Journal for Research in Mathematics Education, 32, 28-57.
10. *Chief Examiners' Report Mathematics*. 2008: (In press).
11. *Chief Examiners' Report Mathematics.* 2009: (In press).
12. *Chief Examiners' Report Mathematics*. 2011: (In press).
13. *Chief Examiners' Report Mathematics*. 2012: (In press).
14. Daley, B. J. (2003). *Learning in teacher professional development.* Paper presented at the Midwest Research-to-Practice Conference. Columbus, Ohio. Retrieved from http://www.alumniosu.org/midwest/midwest%20papers/Daley--Done.pdf.
15. Education Commission of the States. (2000). In pursuit of quality teaching: Five key strategies for policymakers. Denver: Education Commission of the States. Retrieved from http://www.ecs.org/clearinghouse/35/92/3592.pdf.
16. Ernest, P. (1989). *The impact of beliefs on the teaching of Mathematics*. In Press Ernest (Ed.), *Mathematics teaching: The state of the art* (pp. 249-254). New York: Falmer.
17. Fennema, E., Carpenter, T. P., Franke, M . L., Levi, L., Jacobs, V. R., & Empson, S. B. (1996). A longitu-dinal study of learning to use children's thinking in mathematics instruction. *Journal for Research in Mathematics Education*, *27*(4), 403-434.

18. Ferguson, R. L. (2007). Constructivism an research lens, In G. M. Bodner, and M. Orgill, (eds.) Theoretical Framework for research in chemistry education. Upper Saddle River, N.J: Prentice Hall.

19. Ganser , T. (2000). An ambitious vision of professional development for teachers. *NSSAP Bulletin, 84*(618), 6-12.

20. Glatthorn, A. (1995). Cooperative professional development: peer centered options for teacher growth. *Education Leadership, 45*(3), 31-35.

21. Garet, M., Porter, A., Desimone, L. Birman, B., & Yoon, K. (2001). *What makes professional development effective? Analysis of a national sample of teachers*. American Education Research Journal, 38(4), 915-945.

22. Grossman, P.L. (1990). *The making of a teacher: Teacher knowledge and teacher education.* New York: Teachers College Press.

23. Grossman, P.L. (1989). *A study in contrast: Sources of pedagogical content knowledge for secondary English.* Journal of Teacher Education, 40(5), 24-32.

24. Guskey, T. R. (2002). *Professional development and teacher change. Teachers and Teaching: Theory and practice*, 8(3/4), 381-391. doi: 10.1080/13540600210000051 2.

25. Haller, S.K. (1997). *Adopting probability curricula: The content and pedagogical content knowledge of middle grades teachers.* Unpublished doctoral dissertation, University of Minnesota.

26. Hein, G. E. (1991). Constructivist learning theory. Paper presented at the. CECA Conference. Jerusalem, Israel. Retrieved from http://www.exploratorium.edu/ifi/resources/constructivistlearning.html

27. Holloway, J. H. (1999). Caution: Constructivism ahead. *Educational Leadership, 57*(3), 85-87.

28. Hoover, W. A. (1996). The practice implications of constructivism. *SEDLetter, IX*(3).

Retrieved from http://www.sedl.org/pubs/sedletter/v09n03/practice.html

29. Kennedy, M. M. (1998*). Form and substance in in-service teacher education (Research monograph* (13th ed.). Arlington, VA: National Science Foundation

30. Knowles, M. S. (1990). *The adult learner: A neglected species* (4th ed.). Houston: Gulf Publishing Company.

31. Lloyd, G. (1999). *Two teachers' conceptions of a reform-oriented curriculum*: *Implications for mathematics teacher development*. Journal of Mathematics Teacher Education, 2, 227-252.

32. Loucks-Horsley, S., Hewson, P. W., Love, N., & Stiles, K. E. (1998). *Designing professional development for teachers of science and mathematics*. Thousand Oaks, CA: Corwin

33. Loughran, J., Milroy, P., Berry, A., Gunstone, R., & Mulhall, P. (2001). Documenting science teachers' pedagogical content knowledge through papers. *Research in Science Education,* 31, 289-307.

34. Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical. content knowledge. In J. Gess-Newsome and N. B. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 95-132). Retrieved from http://www.jstor.org/stable/3202180.

35. Mbugua K.Z, Kibet K., Muthaa G.M, Nkonke R.G. (2012) *Factors Contributing to Students' Poor Performance in Mathematics at Kenya Certificate of Secondary Education in Kenya*: A Case of Baringo County, Kenya. American International Journal of Contemporary Research, 2(6)

36. Merriam, S. (2001). Andragogy and self-directed learning: Pillars of adult learning theory [Electronic version]. *New Directions for Adult and Continuing Education,* 89, 3-13.

37. Merriam, S. B., & Caffarella, R. S. (1991). *Learning in adulthood.* San Francisco: Jossey-Bass Publishers.

38. Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: John Wiley & Sons.

39. Murphy, E. (1997). Constructivism: From philosophy to practice. Retrieved from http://www.stemnet.nf.ca/~elmurphy/emurphy/cle.html

40. Peredo, M. W. (2000). Directions in professional development. National Clearinghouse for Bilingual Education. Retrieved from http://www.ncela.gwu.edu/pubs/reports/directions/.

41. Perrott, E. (1982). *Effective Teaching*: A Practical Guide to Improve Your Teaching. London: Longman.

42. Perkins, D. (1999). The many faces of constructivism. *Educational Leadership,* 57(3), 6-11.

43. Prawat, R. S., & Floden, R. E. (1994). Philosophical perspectives on constructivist views of learning [Electronic version]. *Educational Psychologist, 29*(1), 37-48.

44. Pritchard, A. (2010). *Ways of learning: learning theories and learning styles in the classroom*. (2nd ed.). London: Routledge.

45. Putnam, R.T. (1992). *Teaching the "hows" of mathematics for everyday life: A case of a fifth-grade teacher.* Elementary School Journal, 93(2), 163-177.

46. Robson, C. (1995). *Real word research:* A resource for social scientists and practitional-Researchers, Great Britain, Padstow: T. J. Press Ltd.

47. Segall, A. (2004). Revisiting pedagogical content knowledge: the pedagogy of content/the content of pedagogy. *Teaching and Teacher Education 20,* 489-504.

48. Shields, P. M., Marsh, J. A., & Adelman, N. E. (1998). *Evaluation of NSF's Statewide Systemic Initiatives (SSI) Program:* The SSIs' impacts on classroom practice. Menlo Park, CA: SRI.

49. Shulman, L.S (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57, 1-22.

50. Shulman, L. S. (1986). *Those who understand: Knowledge growth in teaching*. Educational Researcher.

51. Smith, M. S., & O'Day, J. (1991). Putting the pieces together: Systemic school reform (CPRE Policy Brief, RB-06-4/91). New Brunswick, NJ: Consortium for Policy Research in Education.

52. Spillane, J. P., & Seashore Louis, K. (2002). School improvement processes and practices: Professional learning for building instructional capacity. *Yearbook of the National Society for the Study of Education, 101*(1), 83-104.

53. Tight, M. (2002). *Key concepts in adult education and training* (2nd ed.). London: Routledge Falmer.

54. Trends in International Mathematics and Science Study. TIMSS. Reports. 2007 (In press).

55. Weiss, I. R., Montgomery, D. L., Ridgway, C. J., & Bond, S. L. (1998). *Local systemic change through teacher enhancement:* Year three cross-site report. Chapel Hill, NC: Horizon Research, Inc.

56. Wood, F. H., & Thompson, S. R. (1993). Assumptions about staff development based on research. *Journal of Staff Development, 14*(4), 52-57.

57. Wilson, S. M., & Lowenberg, D. (1991). Changing visions and changing practices: Patch works in learn-ing to teach mathematics for understanding. Research Report 91-2. East Lansing, MI: The National Center for Research on Teacher Education.

58.