한국학교수학회논문집 제 13 권, 제 4 호
Journal of the Korean School Mathematics Society
Volume 13, Number 4, 619-633, December 2010

Promoting Teacher Learning: Implications for Designing Professional Development Programs[1]

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To offer insights in organizing professional development programs to promote teachers' substantial ongoing learning, this paper provides an overview of situative perspectives in terms of cognition as situated, cognition as social, and cognition as distributed. Then, it describes research findings on how mathematics teachers can enhance their knowledge and thus improve their instructional practices through participation in a professional development program that mainly provides opportunities to learn and analyze students' mathematical thinking and to perform mathematical tasks through which they interpret the understanding of students' mathematical thinking. Further, it shows that a knowledge of students' mathematical thinking is a powerful tool for teacher learning. In addition, it suggests that teacher-researcher and teacher-teacher collaborative activities influence considerably teachers' understanding and practice as such collaborations help teachers understand new ideas of teaching and develop innovative instructional practices.

Key Words: mathematics teachers, teacher learning, teacher knowledge, professional development, situative perspectives

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1) This work was supported by the Sogang University Research Grant of 2009.
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I. Changes in Perspectives

Mathematics teachers provide experiences for students' mathematical learning through which not only help students understanding of mathematics and capability to use their understanding to solve problems, but also shape their confidence in and disposition towards mathematics (National Council of Teachers of Mathematics [NCTM], 2000). That is, mathematics teachers should be able to teach for student understanding, which is considered as effective teaching. Then, how do teachers become effective teachers? And what should they change in their classroom instruction for effective mathematics teaching?

For reform in mathematics education, NCTM Standards (1991, 2000) demand substantial changes in teaching practice of mathematics teachers. The role of teachers in mathematics teaching is critical in that teachers are keys to change the ways of mathematics teaching and learning (NCTM, 1991). The changes in classroom practices, however, depend on teachers, particularly, teachers' continuous learning to enhance their knowledge and meaningful experiences for teaching practice. In order to align with the current reform movement in mathematics education, mathematics teachers need to develop "proficiency in teaching mathematics" (National Research Council, 2001), related to their effectiveness, in which students can develop their mathematical proficiency that is interwoven with conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Developing proficiency in teaching practice requires teachers' ongoing learning to increase their pedagogical content knowledge in mathematics. In particular, proficient teaching requires that mathematics teachers have: (a) conceptual understanding of the core knowledge; (b) fluency in performing instructional routines; (c) strategic competences in planning and dealing with problems during instruction; (d) adaptive reasoning; and (e) productive disposition toward mathematics, teaching, learning and practice improvement (National Research Council, 2001). In particular, teaching proficiency can be attained through knowledge base of teachers, knowledge of and understanding mathematical content, knowledge of pedagogical strategies, and understanding about students to reasonably adjust their instruction. Effective or proficient teaching can be achieved by the teachers' mathematical pedagogical content knowledge (Shulman, 1986) or mathematical knowledge for teaching (Ball, Lubienski & Mewborn, 2001) that consists of several kinds of knowledge such as mathematical knowledge, understanding about students, and knowledge of pedagogy (Ball, Heather & Bass, 2005; Ball, Lubienski & Mewborn, 2001;

Gess-Newsom, 1999; Shulman, 1986).

Pedagogical content knowledge of mathematics or mathematical knowledge for teaching (Ball, Lubienski & Mewborn, 2001) is essential for mathematics teachers to teach mathematics well. The concept of pedagogical content knowledge, which is initially coined by Shulman (1986), implies that teachers must not only know the content of mathematics in depth and conceptually, but also know the common and useful representations of particular ideas or concepts for students (Ball, Hill & Bass, 2005; Ball, Lubienski & Mewborn, 2001; Gess-Newsom, 1999; Hill, Rowan & Ball, 2005; Shulman, 1986). First of all, mathematics teachers' mathematical knowledge plays a key role in their teaching. It affects both what mathematics they teach and how they teach it (Ball, 1991, 2000; Ball & Bass, 2000; Ball, Hill & Bass, 2005; Ball, Lubienski, & Mewborn, 2001; Ball & McDiarmid, 1990; Hill, Rowan & Ball, 2005; Ma, 1999). Teachers' mathematical knowledge for teaching also influences how they represent the nature of knowing mathematics to their students (Grossman, 1995; Hill, Rowan & Ball, 2005; Stylianides & Ball, 2008). It is mathematical knowledge that plays a key role in teaching practice; however, effective teaching requires more than knowing mathematics. Knowing mathematics is not sufficient for teaching well in that "mathematical knowledge alone does not translate into better teaching" (Cooney, 1999, p. 166). Thus, for their mathematics teaching to be effective, mathematics teachers should know and deeply understand mathematics, students as learners, and pedagogical strategies, as well as be capable of using that knowledge flexibly while teaching mathematics. Mathematics teachers to teach well should know mathematics in ways that enable them to help students learn mathematics.

The teachers can enhance their mathematical knowledge for teaching through their teaching practice in classrooms, which may be accelerated by their reflection on their practices and support from professional development. This is where teachers' learning occurs and explains that teachers' learning is naturally dependent on their classroom practices as well. As a result, the teachers are to be ongoing learners to be proficient. Teachers are learners but need stimulation and support to improve and change their teaching practices. Mathematics teachers should be continuously exposed to learning opportunities and resources in order to enhance and refresh their knowledge for effective teaching (NCTM, 2000). What mathematics teachers know limits what is done in their classrooms and ultimately what their students learn. With an extensive knowledge of pedagogical content knowledge of mathematics, mathematics teachers can structure their mathematics teaching to encourage their students to continue to learn mathematics (Fennema & Franke, 1992; Hill, Rowan & Ball, 2005; Ma, 1999; Stylianides & Ball, 2008). Without such knowledge, mathematics teachers cannot help their students appropriately.

Research studies suggest that as knowledge base developing proficiency in teaching, pedagogical content knowledge of mathematics or mathematical knowledge for teaching strongly supports a perspective of teaching as a profession and teachers as professionals (Grossman, 1995; National Research Council, 2001). As professionals, teachers can maintain and develop their mathematical knowledge for teaching through collaboration with their colleagues in practices upon which they build learning communities of practice (Sztajn, Hackenberg, White, & Allesaht-Snider, 2007; Wenger, 1998). Another way that mathematics teachers can continue to learn is to participate in effective professional development programs that enable to create contexts for teacher collaboration (Stein & Brown, 1997; Sztajn, Hackenberg, White & Allesaht-Snider, 2007).

I attempt to examine research studies that investigated how teachers learn and such learning should be supported. In particular, I focus on research studies that are theoretically framed with situative perspectives and explore them in order to offer insights in designing and organizing professional development programs for mathematics teachers to improve their practices in mathematics classrooms. In the following sections, I illustrate briefly what situative perspectives suggest for learning and teaching and then how teachers enhance their knowledge through professional development.

II. Situative Perspectives

In providing continuous learning opportunities for teachers, situative perspectives, as ideas about the nature of knowing, thinking, and learning, has provided a lens for understanding how teachers learn new ways of teaching and how teacher learning should be continuously supported (Greeno, Collins, & Resnick, 1996; Putnam & Borko, 2000). Research studies reveals the importance of exploring situative perspectives to understand how competence in mathematics develops (Cobb, 1994; Lampert, 1990).

According to Greeno, Collins, and Resnick (1996), situative perspectives view knowledge as distributed among people and their environments, such as tools, artifacts, books, and object, and their communities and practices in which they participate. In other words, knowing, from this point of view, is an activity that is situated with regard to individual's position in social circumstances; individual activity is an act of participation in the system of practices (Cobb & Bowers, 1999). Consequently, knowing is practices of communities (Lave, 1988; Wenger, 1998). Based on the view of knowing, learning in situative viewpoint is the strengthening of such practices and abilities of participation; namely, learning occurs through participation. For instance, in mathematics classroom, individual students learn when they participate in and contribute to the development of the mathematical practices in the classroom community (Cobb & Bowers, 1999).

Brown, Collins, and Duguid (1989) argue that knowing or knowledge construction is not only naturally situated but also, a part of product of the activity, context, and culture in which knowledge is developed and deployed. That is, activity and situations are integral to learning and cognition and activity, concept, and culture are interdependent and necessary for meaningful learning. They also suggest that authentic activities are "the ordinary practices of the culture" (p. 34) and school activities should be authentic that featured as coherent, meaningful, and purposeful activities since activities provide experiences. Furthermore, they propose cognitive apprenticeship, which enables to enculturate students into authentic activities through activity and social interactions.

Situative perspectives include three conceptual themes, which are cognitive processes are situated in physical and social contexts, cognition is naturally social, and cognition is distributed across people and tools (Putnam & Borko, 2000; Borko, 2004). First, the perspective of cognition as situated suggests that what is learned are integral parts of the ways a person learns and the situation in which a person learns (Greeno & the Middle School Through Applications Project Group, 1998). Moreover, this perspective emphasizes person-situation interaction among people and materials and tools (Cobb & Bowers, 1999) and importance of authentic activities for learning (Brown et al, 1989). The view that cognition is social in nature suggests that learning is social and enculturation processes in which learners come to know how to participate in discourse communities and practices by using the concepts and reasoning of such communities (Cobb & Bowers, 1999; Greeno et al., 1996; Lampert, 1990; Lave & Wenger, 1991). Finally, situative perspective conjectures that cognition is distributed throughout individual, people, and tools (Greeno et al., 1996; Lave, 1988). Taken together, situative perspectives mean that "thinking is situated in a particular context of intentions, social partners, and tools" (Greeno et al., 1996, p. 20).

Situative perspectives provide significant implications for teacher learning as well as student learning. Teacher learning occurs through their classroom teaching practice, their participation in school communities, and professional development (Borko 2004; Carpenter & Franke, 1996; Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996; Fennema &

Franke, 1992; Franke & Kazemi, 2001; Putnam & Borko; 2000; Stein, Silver, & Smith, 1998; Sztajn, Hackenberg, White, & Allesaht-Snider, 2007). In particular, I describe in this paper research findings on: (a) how a professional development program can help teachers increase their knowledge and change their instructional practices; and (b) how teacher-researcher collaborative activities influence teachers' understanding and practice.

III. Support for Teacher Learning

1. Knowledge Growth through Cognitively Guided Instruction (CGI) Professional Development

Teachers' knowledge growth is likely to initiate fundamental change of their teaching practice. In particular, their increase of the knowledge of students' thinking and learning influence change of instructional practice (Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996; Fennema & Franke, 1992). Cognitive Guided Instruction (CGI) project investigates the teaching and learning of addition and subtraction in the first grade for 4 years. The CGI teacher development aims at enabling teachers to understand their students' thinking processes by helping them connect children's understanding of specific concepts of mathematics that research has revealed with their own students' thinking through reflection and thus, to make fundamental changes of their instructional practice (Carpenter & Franke, 1996; Fennema et al., 1996; Franke & Kazemi, 2001).

According to the reports (Carpenter & Franke, 1996; Fennema et al., 1996), the assumption of CGI program is that such knowledge about students' thinking provides teachers with both a basis for understanding students' thinking and a framework for teachers' knowledge of mathematics and pedagogy; thus, teacher development is designed by focusing on children's thinking. In particular, they claim that it is the understanding of students' thinking through which teachers increase their understanding of mathematics, based on studies showing that teachers are more likely to increase the knowledge of mathematics and to modify their instruction as they gain knowledge of their students' thinking. Teachers involved in CGI start with a research-based model of children's mathematical thinking that is built on research about children's solutions to various problem situations so that they obtain perspectives of basic number concepts and operations and children's typical ways of thinking about them. CGI teacher development provides teachers with activities that enable them to interact with the assumption and with opportunities in which they interpret the knowledge of students' mathematical thinking through interactions with students. In addition, the program provides a framework for teachers so that they can construct and examine their own models of students' mathematical thinking to guide their classroom practices.

The teacher development program of CGI consists of workshops in which teachers participate and support provided in their classrooms (Fennema, Carpenter, Franke, Levi, Jacobs & Empson, 1996). In the workshop, after a research-based model of elementary students' mathematical thinking is presented, videotaped examples of individual children solving word problems are shown, which is followed by the teachers' discussion about students' solutions to problems. In so doing, the teachers are led to examine how those solutions of the children presented are similar and different, significant differences between the problem types, how those differences are related to the children's solutions and general principles of the children's approach in solving problems. The teachers are provided with written materials that illustrate the analyses of children's thinking in the videotapes. In order to support teachers in their classrooms, CGI staff members and a mentor teacher visit the classrooms and interact with the teachers to help them use what they learn on children's thinking during workshops.

It is suggested in a follow-up study with selected teachers who participated in the CGI teacher development program that teachers understand and value children's various ways of solving problems as they construct in their own way and how powerful children's communication about their thinking are (Fennema et al., 1996). In addition, most of the teachers show change in their perception of their role as teachers; they come to believe that their role is to create an environment in order for children to develop their knowledge and understanding of mathematics by engaging in problem solving experiences and discuss and share their problem solutions with their teacher and peers. This recognition leads the teachers to realize the importance of providing appropriate problems and questioning skills when they discuss their solutions and thinking. In order to provide such environment, the teachers use their knowledge of the research-based model as a framework for developing profound understanding of children's thinking as well as when selecting problems. "These teachers continually reflect on, modify, and expand their own model of children's thinking in light of what they learn from their students" (Fennema et al., 1996, p. 432). Furthermore, the study shows that knowledge of children's thinking is a powerful tool by which teachers transform and use such knowledge to result in change in their instructional practice. It is also worthy of noting that the knowledge of children's thinking is dynamic, growing, and can be only obtained in the context of mathematics teaching practice. Actual experiences of observing their students constructing solutions to complex mathematical questions reinforce their interactions with their own students and change in their teaching practice (Knapp & Peterson, 1995).

2. Understanding and Practice through Collaboration in Project-Based Instruction

Reform in education would not be successful unless teachers are not properly supported in ways that they can change their classroom practices. Although it is not easy to achieve in short period of time, it is worthwhile to make efforts for teachers to transform their orientation to classroom organization, activities, and interaction with students (Krajcik, Blumenfeld, Marx, & Soloway, 1994).

Based on research on teacher learning that suggests teachers construct their knowledge through social interactions, Krajcik et al. (1994) work collaboratively with middle school teachers to enact project-based instruction in science. The goals of the collaborative work include working with teachers to examine problems that they encounter in their instructional practices and identifying forms of collaboration that help teachers resolve such difficulties. For the purposes, they develop a model of collaboration, enactment, and reflection; teachers collaborate with their colleagues and university researchers in ways that they discuss ideas, plan and enact projects, reflect their experiences, and discuss their difficulties and strategies during the whole processes. Therefore, their work with teachers "is based on a dynamic interplay of three elements found to promote teacher learning, collaboration, classroom enactment, and reflection" (p. 490). Collaboration provides opportunities in which teachers and university staff and consultants share and discuss ideas, plans, and classroom enactments. Enactment entails the planning and carrying out of new practices in classrooms" (p. 492). Finally, it is reflection that leads substantially teachers' growth in their knowledge. Teachers can write a journals for reflection by describing their daily or weekly experiences of change and thinking upon them.

In particular, collaboration is crucial in the work because collaboration helps teachers understand new ideas of teaching and develop innovative instructional practices (Ball & Runquist, 1993). Furthermore, collaboration is not only central to develop socially constructed meaning, but also helpful to overcome the isolation of teaching (Lave & Wenger, 1991). Teachers learn through collaborative opportunities; thus, it is important to create opportunities for their professional development in which they can not only discuss difficulties, experiences from their own classroom, and pedagogical skills, but also support each other (Blumenfeld, Krajcik, Marx, & Soloway, 1994).

Based on the model of the cycles of collaboration, classroom enactment, and reflection, Blumenfeld et al. (1994) describe how the collaborative work of teacher and researcher and among teachers influence changes in the teachers' understanding and practice. To build collaboration with middle school teachers in science, Blumenfeld et al. start communicating through telecommunications and structured interviews and provide work sessions in which teachers and researchers explore ideas and conceptions about teaching and learning through group conversations. In working collaboratively, the teachers and university researchers not only share ideas, experiences, and strategies for enacting projects in their classrooms but critique each others' plans and enactments within project-based instruction. Moreover, the teachers, through collaboration, are provided support and information on content, activities, and features of project-based instruction. Over time, teachers change in ways that they become more willingly involved in discussion about their problems and difficulties. Most important, although the teachers' initial enactments in accord to the project-based instruction are rough, as time goes by, they begin to use practices that need considerable students involvement and active thinking in their instruction, which is one of the goals of the project-based instruction in science. Through conversations during the collaborative work sessions, teachers exchange their experiences of their students' participation, which motivate them to develop strategies and to encourage each other to find alternative effective ways to help their students.

Ladewski, Krajcik, and Harvey (1994) illustrate how one teacher participating in their work gains understanding and learns to use such understanding in her classroom. The teacher develops new possibilities and instructional strategies and refines previous ones. Most of all, it is opportunities for collaboration and reflection that support the teacher's enactment. Based on the results of this study on the teacher, Ladewski et al. suggest that the opportunities of collaboration with teacher colleagues and researchers support the teachers' learning process. In addition, they suggest that

if teachers are to develop complex new conceptions, strategies, and possibilities for instruction, their teaching environments need to support that learning process by providing interactive and repeated cycles of enactment, collaboration, and reflection rather than the single isolated opportunities that are characteristics of traditional teacher enhancement efforts. (p. 514)

IV. Summary and Conclusions

The purpose of this paper is to propose ideas that would be helpful to design effective professional development programs for mathematics teachers in which they can continue to learn for change in their instructional practice by examining teacher development programs in the United States. The continuous learning, ultimately, would result in improving mathematics instruction aligning with reform in mathematics education. In particular, in my opinion, there would be an urgent need for redesigning effective professional development programs to promote teachers′ ongoing learning in Korea.

I have taken the view of situative perspectives in examining some efforts that promote teachers′ learning and described situative perspectives by which means in terms of the nature of knowing and learning and three themes in the situative perspectives. I have then sketched out the general features of CGI and project-based instruction with regard to the support for teachers in which teachers′ learning occur by focusing on teachers′ knowledge increase through workshops and classroom support in CGI and teachers′ change in understanding and practice through collaborative work in project-based instruction.

Teacher development in CGI follows the situative perspective of authentic activities; the program is situated within contexts in which teachers can bring their teaching experiences and connect them with activities in the program. As a consequence, the activities provided in the program are meaningful and purposeful so as to increase the teachers′ knowledge and understanding of students′ mathematical thinking. Learning students′ thinking processes and building them on their own understanding from experiences with their students in classroom contexts in experiences are totally situated in their practice (Franke & Kazemi, 2001).

Teacher-researcher and teacher-teacher collaboration in project-based instruction contributes to teachers′ learning and change in their instructional practice. This also supports the situative perspectives that explain learning is distributed through people and physical contexts and hence, cognition is social in nature. Through collaboration with colleagues and university researchers, teachers gain enhanced understanding about their students and content they teach, which results in change in their classroom enactment.

For reform in mathematics education that emphasizes thinking processes and discourse in mathematics classroom by sharing and discussing ideas and inventing solutions as well as students' conceptual understanding, teachers should be provided and supported to experience and learn new ways of fostering such thinking processes and discourse and to have flexible knowledge of mathematical content. Unless teachers plan and select mathematical tasks for students to participate in discourse about concepts, claims, and arguments, the students cannot experience such discourse in mathematics learning (Greeno et al., 1996). Besides, teachers should be able to facilitate those experiences. To successfully achieve this, teachers must learn and challenge themselves continuously. To successfully achieve this, teachers must learn and challenge themselves continuously since most teachers did not have such experiences as learners. Further, they should be provided appropriate learning opportunities in which they can refresh and fill the gap in their knowledge and to develop flexible understanding.

What is important in supporting teachers' learning is to organize effective professional development programs in which teachers' learning occurs in relation to their classroom teaching practices; hence, they can develop and enhance their knowledge of students' understanding in situated contexts by having opportunities to examine how students make sense mathematical ideas, what they do not know and have trouble understanding particular mathematical concepts and ideas, students' learning processes, and students' common errors and misconceptions in mathematics learning. Furthermore, professional development programs should focus on providing teachers with experiences in which they engage in activities of solving mathematical problems as learners for developing their flexible, thus powerful, understanding of mathematics. These experiences ultimately lead teachers to improve their own understanding of mathematics and pedagogy. In particular, group discussions can be implemented in regard to how to solve problems teachers face in their teaching such as pedagogical strategies for particular situation and understand each other's ideas in designing high-quality learning environments for teachers (Greeno et al., 1996). What is more, in so assisting teachers' learning, teachers should be encouraged in a way that they actively and willingly involve in collaboration with their colleagues and people such as experts in content and researchers in education for their ongoing learning, which results in substantial changes in their teaching practice.

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수학교사의 수업전문성 신장을 위한 교사 연수 프로그램 개발의 기본 관점

김구연[3)]

초 록

이 연구는 교수학습 이론에서 상황이론을 토대로 미국의 수업 전문성 신장 실천 사례를 분석하고 교사의 학습 지원 방향을 탐색한 문헌 연구이다. 연구의 목적은 수학 교사의 수업활동 개선을 위해 교사의 학습 지원에 효과적인 프로그램의 유형을 탐색하는 데 있다. 연구 내용은 교사의 새로운 교수학습 방법 학습에 관한 상황이론의 내용 분석과 미국의 수업 전문성 신장 프로그램 운영 사례 분석으로 설정하였다. 상황이론은 인지활동이 상황적, 사회적, 그리고 분산적으로 일어난다고 설명한다. 나아가 상황이론은 수업활동의 변화를 위한 교사의 새로운 교수 방법에 대한 학습과 그러한 교사 학습을 어떻게 계속적으로 지원해야 하는 가에 대한 틀을 제공한다. 첫째, 수업전문성 신장을 위한 교사 연수 프로그램은 실제 수학적 태스크 활동을 통해 살펴보고 수학 학습자의 수학적 사고과정을 분석하는 기회를 제공해야 한다. 학습자의 수학적 사고과정에 대한 이해는 교사학습에 매우 중요한 실제적인 도구다. 둘째, 수업전문성 신장을 위한 교사 연수 프로그램은 교사-교사 혹은 교사-연구자의 협력적 활동을 장려하도록 개발하는 것이 중요하다. 협력적 활동은 교사의 지식 증대와 효과적인 수업활동을 촉진하며, 협력을 통해 교사들은 새로운 교수 방법에 노출될 뿐만 아니라, 보다 혁신적인 수업활동을 개발하고 적용할 수 있게 한다.

주요용어: 수학 교사, 교사 학습, 교사 지식, 전문성 신장, 상황이론의 관점

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