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Teacher Efficacy in Relation to Mathematics Reform: A Look at a Collaborative Group of Elementary Teachers

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TEACHER EFFICACY IN RELATION TO MATHEMATICS EDUCATION REFORM: AN EXAMINATION OF A PROFESSIONAL DEVELOPMENT STUDY GROUP OF ELEMENTARY TEACHERS

by

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ABSTRACT

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A number of recent efforts to improve mathematics instruction have focused on professional development activities designed to promote changes in teachers' practice that are consistent with the standards of the National Council of Teachers of Mathematics [NCTM]. Since teacher beliefs can have a significant influence on what teachers do in their classroom, this study investigated the impact of an alternative form of professional teacher development designed to impact both general and personal teacher efficacy beliefs toward the use of *Standards*-based mathematics. A professional teacher development study group [PDSG] was formed that consisted of a facilitator/participant and six elementary teachers who were interested in improving their mathematics instruction. The group met over a period of six months in eight sessions to examine their own mathematical thinking and beliefs as well as the mathematical thinking of children. Results indicated that general and personal teacher efficacy changed in a positive direction toward the use of *Standards*-based mathematics. These results suggest that the

implementation of mathematics reform may be facilitated when teachers have the opportunity to engage in a PDSG specifically designed to attend to teacher efficacy beliefs and support positive changes in those beliefs.

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CHAPTER 1

INTRODUCTION

In response to current mathematics education reform efforts, which began in the 1980s in the United States, a growing number of schools and teachers nationally are becoming aware of and are attempting to implement reform- or *Standards*-based mathematics instruction. Guidelines for *Standards*-based mathematics instruction are described by the National Council of Teachers of Mathematics [NCTM] for teaching mathematics (Brosnan, Edwards, & Erickson, 1996; National Center for Improving Student Learning and Achievement in Mathematics and Science [NCISLA]/Mathematics & Science, 2004; National Council of Teachers of Mathematics [NCTM], 1989, 1991, 1995, 2000; Pligge, 2000). These guidelines, which are grounded in a constructivist view of teaching and learning (Cooney & Shealy, 1997), emphasize teaching mathematics in ways that increase students' thinking and understanding about mathematics as opposed to rote memorization of facts and algorithms (NCTM, 1989, 1991, 2000).

In spite of research that shows positive student achievement when these guidelines are used (Brosnan, et al., 1996; Lewis, 2006; Martinez & Martinez, 1998; Riordan & Noyce, 2001), the progress of implementation is slow and at times seemingly nonexistent. Current research seeks to explain why this is so. One explanation for this phenomenon is teachers' response to the messages of reform. Studies indicate that because teachers play an essential role in the success or failure of reform (Battista, 1994; De Mesquita & Drake, 1994; Fullan, 1991, 1993), their ability or inclination to implement changes in their practice and their interpretation of educational reform can either facilitate or constrain its enactment (Battista, 1994). As Fullan (1991) asserted, educational reform relies primarily on what teachers do and think; their knowledge, beliefs, and attitudes play a vital role in school change processes. Battista (1994) supported this argument, suggesting, " . . . once they fully understand and believe in the reform movement, teachers will lead the way in implementing it" (p. 470). In short, the way in which a teacher understands and responds positively or negatively to reform will likely determine the level of his or her participation in implementing it.

While teachers potentially lead the way in reforming what happens during mathematics instruction, extensive change in teachers' classroom practice may be needed first in order for reform to occur. Specifically, classroom instruction will need to align with the tenets of reform-based mathematics (Frykholm, 2004; Heibert, 1999; Sirotnik, 1999). However, it is difficult to get teachers to change the way they teach (Heibert, 1999; Wood, Cobb, & Yackel, 1991). Researchers have identified three reasons for the challenge. First, in order for teachers to change the way they teach mathematics, they must have opportunities to learn mathematical content and pedagogy in new ways (Darling-Hammond & Ball, 1998; Loucks-Horsley & Matsumoto, 1999; Remillard & Bryans, 2004). However, few opportunities for learning these methods of teaching are available to many practicing teachers (Heibert, 1999). Second, De Mesquita & Drake (1994) posited that the demands that are placed on teachers to implement mathematical reform may be asking them to teach in ways for which they have no formal preparation and little understanding. Indeed, without adequate conceptual support, it is unreasonable to expect teachers to be capable of implementing new methods of teaching mathematics. Finally, Battista (1994) noted that teachers might have beliefs about mathematics instruction that are incongruent with the goals of mathematics reform. He argued that these beliefs play a key role in what and how teachers teach and, as a result, this incompatibility is an ongoing obstacle to reform. As Fullan (1991) suggested, "You cannot force [people] to think differently or compel them to develop new skills" (p. 23).

Because of the critical nature of the effects of teachers' beliefs on the success or failure of mathematics reform, comprehending specific teacher beliefs that may influence reform and understanding how those beliefs can be influenced has become an important focus of teacher educators and researchers (Barlow, 2006; Brosnan, et al., 1996; Rouseau, 2004; Thompson, 1992; Warfield, Wood, & Lehman, 2005; Wood, Cobb, & Yackel, 1991). Indeed, Brosnan and her colleagues (1996) state that

> Any attempt to improve the quality of mathematics teaching must begin with an understanding of the conceptions held by teachers and how these are related to their instructional practice. Failure to recognize the role that teachers' beliefs might play in shaping their behavior is likely to result in misguided efforts to improve the quality of mathematics instruction in schools. (p. 36)

Therefore, attempts to improve the quality of mathematics instruction in schools should be accompanied by careful consideration of teachers' beliefs in relation to their practice.

Thompson (1992) summarized the research about teachers' beliefs or conceptions that may influence what and how they teach mathematics. Included in her list of teachers' beliefs that impact practice are their beliefs about what the goals of the mathematics program should entail, which instructional practices are most effective for teaching mathematics, what constitutes acceptable student outcomes, what roles should be assumed by the teacher and student in the teaching-learning process, and how students think and learn mathematics. Thompson (1992) contended that the research concerning the beliefs teachers have about mathematics suggests that these beliefs play a crucial role in their instructional practices and their inclination or ability to implement reform.

Although teachers maintain a number of beliefs about teaching and learning (Pajares, 1992), all of which influence what happens in their classrooms, one of the most crucial beliefs to emerge in understanding teacher practice in relationship to change is personal teaching efficacy. Bandura (1986) asserted, “Among the different aspects of self-knowledge, perhaps none is more influential in people’s everyday lives than conceptions of their personal efficacy” (p. 390). He described personal efficacy as an individual teacher’s belief in his or her own teaching effectiveness and suggested that teachers may believe that the implementation of certain instructional guidelines can produce specific outcomes but fail to act upon those guidelines because they believe they are incapable of executing them (Bandura, 1977, 1986). Researchers have argued that in order for mathematics reform to move forward, these negative or low self-efficacy beliefs about teaching reform-based mathematics must change (Battista, 1994; Swars, 2005).

How to effect a change in beliefs as it relates to mathematics reform is a question that has been addressed by multiple studies of teacher development programs for both preservice and practicing teachers. In this body of research, two dominant perspectives have emerged. The first is based on the premise that teachers’ behavior is based on what they believe. If a teacher believes that changing the nature of mathematics instruction is unnecessary to improve student achievement, he or she will resist making instructional changes. Therefore, *beliefs must change before practice will change* (Barlow, 2006; Pajares, 1992; Richardson, 1996; Thompson, 1992). The second perspective is espoused by Guskey (1988), who suggests that teachers experience events as they engage in practice that will affect their beliefs. For instance, if student scores increase after a specific teacher action, the teacher's belief that it was an effective action is strengthened. In this case, *beliefs will change as a result of practice*. Both of these perspectives have been used to guide studies of the effectiveness of different approaches to teacher professional development and efforts to alter what teachers do in their classrooms.

Some research in other content areas indicates that a single course or workshop may have the potential to modify teachers' thinking about instruction when these experiences encourage participants to examine and challenge their preexisting beliefs (Cooney & Shealy, 1997; Hollingsworth, 1989; Richardson, 1996). However, a large body of research suggests that long-term teacher development experiences, inquiry and reflection, utilization of new learning, and support over time are necessary for effective change (American Educational Research Association [AERA], 2005; Battista, 1994; Bullough & Baughman, 1997; Day, 1999; Garet, Porter, Desimone, Birman, & Yoon, 2001; Heibert, 1999; Mewborn, 2003; NCISLA, 2004; Richardson, 1996). Battista (1994), for example, notes that the one- or two-day inservice workshops often offered to practicing teachers are insufficient to achieve the change required to meet mathematics reform measures because these truncated, "one-shot" experiences do not address the teachers' underlying beliefs and knowledge. Nor do these short-term interactions with teachers sufficiently instruct them in how students come to an understanding of mathematical ideas. He recommends, instead, initial extensive inservice programs that last for several weeks with continued support and follow-up throughout a year or longer. This finding has been supported by other studies as well (AERA, 2005; Garet, et al., 2001). For example, Garet and his associates (2001) asserted, " . . . the duration of professional development is related to the depth of teacher change" (p. 917).

Much research has been committed to examining changes in teacher efficacy beliefs as they relate to mathematics reform through teacher development (Battista, 1994; Cooney & Shealy, 1997; DeMesquita & Drake, 1994; Huinker & Madison, 1997). However, two areas remain troublesome. First, the bulk of these studies have focused on teacher development through school or district teacher inservice experiences (Cohen & Hickman, 1998), the development of collaborative learning communities (NCISLA, 2002; NCISLA, 2004), and emphasis on enriched experience in methods courses for preservice teachers (Huinker & Madison, 1997). In each of these studies, teacher efficacy beliefs are viewed through the lens of the researcher. However, there is no evidence of the examination of this type of teacher efficacy belief change from the perspective of the teachers themselves. In other words, teacher development committed to changing teacher efficacy beliefs is generally imposed upon them. The question, then, is how do teachers who are engaged in steering their own professional development experience perceive changes in their personal teaching efficacy over time?

Second, such teacher development programs as are recommended above are difficult to sustain and can be costly (Garet, et al., 2001; Haney & Lumpe, 1995). As a result, many teachers have not had opportunities for learning of this kind (Fullan & Hargreaves, 1992; Heibert, 1999) and, therefore, may not experience the kind of situations that encourage or allow them to change their personal teaching efficacy beliefs. In light of this problem, alternative methods of teacher development that support mathematics reform need to be explored. Indeed, it is likely both of these concerns can be addressed by looking at an alternative form of teacher development in which teachers voluntarily engage to improve their practice.

The purpose of this study was to examine change in personal teaching efficacy beliefs of teachers toward reform-based mathematics instruction in response to a specific type of professional development that was enacted as an alternative to traditional teacher development. A case study of this experience involved an examination of a small, collaborative group of teachers who were committed to improving their personal implementation of *Standards*-based mathematics. The group met regularly over a six-month period of time to set goals, study reform-based mathematics, reflect, share feedback, and examine student work. The personal mathematics teaching efficacy of each participant was explored for changes over time during this teacher development experience.

The specific research questions that guided this study were:

1. How does a collaborative group of teachers working together to improve *Standards*-based mathematics instruction evolve? What critical incidents denote the group's evolution? What issues obstruct or facilitate the group's development and interaction as it evolves?

2. Within the context of the current mathematics reform movement, how does the personal and general teaching efficacy beliefs of individuals toward *Standards*-based mathematics instruction within a small group of elementary teachers change over the course of six months as they are engaged in a professional development process designed to be supportive?

CHAPTER 2

LITERATURE REVIEW

This study examined changes in personal and general teaching efficacy of participants within a small collaborative group of teachers as they engaged in a teacher development experience. In order to better understand the background of the study based on current literature relating to the issues of this study, a description of several bodies of literature is required. First, I will describe literature relating to mathematics reform. Then, I will explore topics in relation to educational reform generally and mathematics educational reform specifically including teacher thinking and beliefs, teacher efficacy, and professional development. Finally, I will discuss a synthesis of these ideas by relating the influence of teacher development on teacher efficacy beliefs that, in turn, may influence the implementation of mathematics educational reform.

Mathematics Education Reform

Current mathematics education reform in the United States has it roots in the 1980s, when the nation's schools were reported as being years behind our economic competitors in student achievement, curriculum, and instructional practices (National Research Council [NRC], 1989). A number of national reports focused on what was termed the near-crisis of education in the areas of mathematics and science. Included in this list of documents were *An Agenda for Action* (NCTM, 1980), *A Nation at Risk* (National Commission on Excellence in Education, 1983), and *A Report on the Crisis in Mathematics and Science Education* (American Association for the Advancement of Science, 1984). It was determined that problems stemmed from children's learning being focused on rules and procedures rather than on key conceptual understanding (Heibert &

Carpenter, 1992). The close timing of the occurrence of these independent reports, combined with a severe economic recession in 1981-82, precipitated the need for action toward educational reform (Stake, 1993).

The NCTM responded to national concerns by developing documents addressing the need to improve mathematics education. In 1989 this organization released *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989), a document to articulate goals for teachers in mathematics. Then, *Professional Standards for Teaching Mathematics* (NCTM) was published in 1991, which described effective mathematics teaching. These two documents, which were grounded in a socioconstructivist view of teaching and learning, pointed mathematics education in a new direction. As a result, educators and researchers had to examine their thinking about the very nature of mathematics itself (Nelson, 1997).

The new perspective of mathematics learning and teaching generated a demand for reforms in teacher education and assessment practices. In 1995, the NCTM added *Assessment Standards for School Mathematics* (NCTM, 1995) to set guidelines for assessment practices. Then, in 2000, all three documents were revised, updated, and combined in *Principles and Standards for School Mathematics* (hereafter referred to as the *Standards*) (NCTM, 2000). This document was intended for use in the improvement of mathematics curricula, teaching, and assessment.

The guiding principles of the *Standards* document (NCTM, 2000) along with its socioconstructivist undergirdings, defined new roles for both student and teacher. The document proposed that students' learning of mathematics is more than just evoking facts and procedures. Instead, students need to be actively involved in and responsible for their own mathematical learning. In addition to memorizing and recalling facts, children are expected to problem solve, think critically, reason, discuss, and generate knowledge by exploring solutions to authentic tasks, making conjectures, and developing strategies. In Cobb's (1994) words, "students' initial informal mathematical activity should constitute a basis from which they can abstract and construct increasingly sophisticated mathematical conceptions" (p. 23-24). In short, students need to be actively engaged in building new knowledge from their experiences and prior knowledge. The teacher's role, then, changes from one of transmitting knowledge to one of facilitating the acquisition of knowledge. In order to do so, teachers must understand how children think about mathematics and provide rich intellectual materials and a social environment that attends to, supports, and challenges the mathematical thinking of all their students (Nelson, 1997). Furthermore, the *Standards* advocates that teachers, like students, have similar experiences in developing their own mathematical thinking so that they will have the understanding as well as the ability to empower students as mathematical thinkers (Brosnan, et al., 1996). Finally, the *Standards* support the idea that classrooms should change from simply a "collection of individuals" toward "classrooms as mathematical communities" (Office of Educational Research and Development, 1991, p. 2). In other words, classrooms should become places in which teachers and children work together to achieve mathematical understanding (Bay-Williams & Meyers, 2003).

Major efforts to implement mathematics teaching and learning that align with the *Standards* are currently underway throughout the nation (Edwards, 2003). However, researchers have identified several challenges that affect the progress of implementation, including obstacles presented by teachers, parents, and students (Frykholm, 2004; Hiebert, 1999; Martinez & Martinez, 1998; Weasmer & Woods, 1998). One of these barriers is the contrast between the curriculum objectives of traditional mathematics instruction and those of *Standards*-based mathematics. While traditional mathematics curriculum focuses on memorization of basic facts and mastering algorithms, *Standards*-based mathematics relies on curriculum goals conducive to problem solving, critical thinking, and mathematical understanding (NCTM, 2000). Because teachers are held accountable for teaching to required curriculum goals, they may be hesitant to use teaching methods that they do not view as being aligned with those curriculum goals.

Parents and students also express frustrations about not understanding how to do “new math.” Students in traditional mathematics classrooms have seldom been asked to think about mathematics in robust ways, and they can have a difficult time learning to think in new directions (Stake, 1993). In addition, parents hold expectations that their children’s schooling will be very much like their own (Heibert, 1999; Stake, 1993). As a result, they express frustration when they do not completely understand how to help their children think about mathematics in new ways.

Perhaps the most significant obstacle to mathematics reform, however, is in engaging teachers in mathematics reform. They may face obstacles in their personal understanding of mathematics, the context in which they are accustomed to teaching it, and their conceptions about what mathematics and good mathematics instruction look like (Battista, 1994; Frykholm, 2004). They may even see mathematics reform as a threat to the quality of education and will fight to protect children from it (Stake, 1993). Since teachers' thinking and beliefs largely determine the decisions they make and the way they teach (Pajares, 1992; Richardson, 1996; Thompson, 1992), negative thinking and beliefs about mathematics reform will likely hinder its implementation in the classroom.

In light of these challenges, reformers are looking for effective ways to continue to encourage and support the implementation of the *Standards* (NCISLA, 2004). In doing so, they recognize the significant role that teachers and teachers' thinking about teaching and learning play in the implementation of mathematics reform measures. Clearly, change cannot occur unless teachers believe that reform is beneficial and feel confident in their ability to pedagogically support reform efforts. Therefore, it is crucial to examine teacher thinking and its implications for mathematics reform.

Teacher Thinking and Beliefs in Relation to Mathematics Education Reform

Beginning in the mid-1970s, the paradigms of information processing and cognitive science influenced a shift in research on teaching from the study of teacher behaviors to a focus on teacher cognition (Thompson, 1992). Initial research addressed three areas: (a) teacher thinking processes that influenced planning, (b) teaching as problem solving, and (c) teacher cognition models formed from research on methods of judgment and decision making (Nelson, 1997; Shulman, 1986a).

During the mid-1980s, researchers also began to examine the impact of teachers' content ideas on their teaching (Shulman, 1986b). It was also argued during this time that traditional thinking about the nature of mathematics as a fixed system of ideas needed to change to mathematics as a way of thinking and constructing meaning (Shulman, 1986b).

When the NCTM *Standards* materialized in the late 1980s, four basic notions about the process of changing teacher practice were developing (Nelson, 1997). One idea was based on Piagetian philosophy. From this perspective, teachers needed to participate in activities that would create disequilibrium in their own mathematical thinking and thus, a need for and move toward cognitive reorganization (Schifter, 1996a, 1996b). Through the lens of cognitive science, teacher change was promoted by strategically and specifically focusing on changing and organizing the content knowledge of teachers. From this perspective, teacher change occurred through acquiring and organizing knowledge, relating that knowledge to children's mathematical thinking, and then using that knowledge to guide practice (Carpenter, Fennema, Peterson, & Carey, 1988). The third argument was that teachers' mathematical knowledge needed to shift to become more conceptual and less algorithmic (Nelson, 1997; Shulman, 1986b). The final notion, based a socioconstructivist view, is described in the work of Cobb, Wood, and Yackel (1990; see also Wood, Cobb, & Yackel, 1991). They argued that as teachers changed their classrooms to accommodate student construction and discussion of mathematical ideas, teachers experienced and resolved conflicts between their prior beliefs and what they saw happening in their classroom.

The importance of attending to teacher beliefs has become prominent in educational research over the past 25 years (Kagan, 1992; Nespor, 1987). There are two main explanations for this emphasis. First, research suggests that there is a strong relationship between teachers' beliefs and their actions in the classroom (Pajares, 1992) and that understanding teachers' beliefs can lead researchers to a better understanding of teachers' practice (Richardson, 1996). Indeed, Kagan goes so far as to suggest that teacher beliefs lie "at the very heart of teaching" (p. 85). Additional research points to the cause and effect relationship between positive teacher beliefs and effective teaching behaviors (Tschannen-Moran & Hoy, 2001) and student achievement (DeMesquita & Drake, 1994; Guskey, 1988; 2000; Ross, 1994). For instance, Loucks-Horsley and Matsumoto (1999) note that teachers' prior beliefs affect what they learn and, therefore, how they teach. Darling-Hammond and Ball (1998) further state, "Teachers who know a lot about teaching and learning and who work in environments that allow them to know students well are the critical elements of successful learning" (p. 6). In essence, teachers' beliefs about teaching and learning shape their classroom behaviors and, in turn, may influence student achievement (Huinker & Madison, 1997; Loucks-Horsley & Matsumoto, 1999).

A second explanation for the importance of attending to teachers' beliefs is that they have been shown to enhance or hinder the process of implementing educational reform and innovations (Battista, 1994). For example, in a study of practicing teachers, Guskey (1988) concluded that there are strong relationships between teachers' beliefs and their willingness to implement instructional innovations. In support of Guskey's argument, Loucks-Horsley and Matsumoto (1999) noted that many teachers hold strongly rooted beliefs of "knowledge as facts, teaching as telling, and learning as memorizing" (p. 261). These researchers contend that these beliefs are "anathema to the new reforms" (p. 261) and must be dispelled in order for teachers to teach to new reform measures in science and mathematics. In order for these beliefs to be dispelled, they first need to be identified and understood.

In unlocking the door to facilitating mathematics reform, four key kinds of teacher beliefs need to be considered. First, teachers' beliefs about reform in general can influence their attempts to change. Teachers may question the importance of new practices or assess them as too difficult to implement (Guskey, 1988). Second, teachers' knowledge and beliefs about mathematics affect what and how they teach; their mathematical understanding may be totally incongruent with current mathematics reform. For example, teachers may understand the nature of mathematics to be following procedures invented by others, whereas current mathematics reformers see it as problem solving, thinking, and reasoning where learners construct their own strategies for responding to problems (Battista, 1994). Or, they may not have the necessary conceptual understanding of mathematics (Frykholm, 2004) in order to enact reform. Third, teachers' thinking about how children learn influences the implementation of reform-based instruction. Those who believe children learn from memorizing and practicing rules and procedures will have a difficult time using child-centered learning practices that lead to mathematical understanding (Battista, 1994). Finally, a teacher's sense of his or her own teaching efficacy has a tremendous impact on her or his desire to initiate and continue reform measures (Guskey, 1988; Weasmer & Woods, 1998). This study focuses on the fourth type of belief, teacher efficacy.

Teacher Efficacy

Many current thoughts on teacher-efficacy beliefs are grounded in the social cognitive theory of Bandura (1977, 1986). He defined self-efficacy not as an individual's skills or abilities to perform a designated task, but as one's *perception* of one's skills or ability to perform a designated task (1986). Consequently, two teachers may have similar skills available to them to perform a certain task, but they may perform it at different levels of success depending on their personal self-efficacy.

Teacher efficacy can be considered on two levels: (a) general teaching efficacy and (b) personal teaching efficacy (Bandura, 1986; Weasmer & Woods, 1998). The first term, general teaching efficacy, refers to a teacher's perception that instruction can affect student learning. Bandura (1986) describes this type of efficacy belief as "outcome expectancy" (p. 392), or the perception that *this task can be done*. For example, if a teacher believes that students can learn certain subject matter—that it *can* be taught, he or she will persevere in teaching that subject matter with confidence. Whereas, the teacher who believes that students cannot or will not be able to learn the subject matter through instruction is showing evidence of poor perceptions of outcome expectancy or general teaching efficacy. The second term, personal teaching efficacy, describes a teacher's belief in his or her own effectiveness (Ashton & Webb, 1983; Bandura, 1977), or *I can do it*. This belief may cause teachers either to avoid tasks that they believe are beyond their own personal capabilities, or confidently undertake tasks of which they judge themselves capable (Bandura, 1986). The differentiation between these two levels of efficacy can be illustrated through the teacher who believes that a particular learning outcome can be achieved (general teaching efficacy) but does not act upon it because she or he questions her or his own abilities to execute the required teaching methods (personal teaching efficacy).

Bandura's theory (1986) brings to light the significance of self-efficacy as a critical indicator of behavior. He asserts, "Among the different aspects of self-knowledge, perhaps none is more influential in people's everyday lives than conceptions of their personal efficacy" (p. 390). Huinker and Madison (1997) suggest that positive self-efficacy, combined with skill and knowledge, are essential in performing specific actions. As a result, teachers who see themselves as capable of teaching certain subjects challenge themselves and persist in their efforts to succeed. Such success, in turn, becomes generative because it enhances personal self-efficacy. Conversely, negative beliefs about one's efficacy inhibit performance action and perseverance toward a task (Bandura, 1986).

Research shows a strong correlation between positive self-efficacy beliefs, effective teaching behaviors, and improved student achievement (Ashton & Webb, 1986; Ross, 1992; Tschannen-Moran & Hoy, 2001). Therefore, positive teacher self-efficacy beliefs as related to practice that aligns with the goals of reformers must be considered in order to improve the implementation of *Standards*-based mathematics instruction in schools (Swars, 2005; Thompson, 1984; von Glasserfeld, 1988; Wood, Cobb, & Yackel, 1991).

Teacher Efficacy Beliefs in Relation to Mathematics Education Reform

Mathematics education reform, relies heavily on personal efficacy beliefs (Huinker & Madison, 1997). Frykholm (2004) argued that teachers may be given the freedom to begin teaching based on what children are thinking and doing, and yet, "when not accompanied by equally *strong confidence* and understanding of substantive content, teaching, and learning, [this freedom] can lead to teacher *uncertainty*, *doubt*, and eventually, pedagogical paralysis" (p. 2). The terms, confidence, uncertainty, and doubt, are alternative ways of expressing high or low teaching efficacy beliefs. Mathematics teaching efficacy beliefs can strongly influence teachers' levels of willingness, motivation, energy, and perseverance in implementing mathematics reform. For example, Bandura's theory (1986) would explain that when teachers are required to implement mathematics reform, their classroom instruction will be influenced by their perceptions of whether students can learn mathematics from *Standards*-based mathematics instruction (general teaching efficacy) and by self-judgment of their own ability to change their methods of teaching mathematics(personal teaching efficacy) (Fullan, 1991; Guskey, 1988). Based on this theory, teachers who judge students as being capable of learning from *Standards*-based mathematics and see themselves as capable of changing their mathematics teaching methods will implement the reform measures with confidence and enthusiasm. In contrast, those teachers who doubt students' ability to learn from *Standards*-based mathematics instruction or have low teacher efficacy related to their ability to change, will likely avoid implementation or may implement with reluctance.

Professional Development: Helping Teachers to Implement Reform

Because teachers are the key to mathematics education reform (Battista, 1994; Rousseau, 2004; Warfield, et al., 2005), professional development that is aimed at supporting teachers' efforts to implement reform is central to teacher change (Loucks-Horsley & Matsumoto, 1999). However, traditional professional development practices have come under scrutiny in recent years. These practices have generally taken shape in the form of short-term inservice workshops and college courses (Loucks-Horsley, & Matsumoto, 1999). In a study of professional development by Loucks-Horsley, Hewson, Love, and Stiles (1998) large discrepancies were found between teachers' experiences with professional development and what is known to be effective in teacher development. For example, one-time professional teacher development sessions were criticized for not providing teachers with the opportunity to study their practice in depth. The sessions were shown to lack in critical areas such as focus on subject matter, connections to personal teaching, and opportunities for collegial study (Loucks-Horsley, et al., 1998). Furthermore, Darling-Hammond and Ball (1998) described traditional professional development practices as providing information, teaching generic skills, answering questions, and supplying curriculum. They suggested that more powerful professional development encourages inquiry and active learning and provides opportunities for teachers to develop useful content knowledge.

Darling-Hammond and Ball (1998) further addressed the challenges of helping teachers teach to the *Standards.* In order to do so, they recapped five main points that need to be considered in effective teacher development designed to support the implementation of reform-based practices (see also Ball, 1996). First, teachers' prior experiences and beliefs have a huge impact on what they learn. Beliefs about mathematics as knowledge of facts, teaching as telling, and memorization as learning are detrimental to mathematics reform. Teachers can begin to be taught for understanding only when these beliefs are scrutinized. Second, dispelling these beliefs is not easy and takes time. Even when beliefs are in alignment with reform, changing teacher practices from teaching as telling to teaching as guiding requires time. Third, teachers cannot teach what they do not know. They need to have the content knowledge necessary to teach in a manner that helps students gain understanding of mathematical concepts. They also need to understand the context of the experiences and abilities of the students they teach. Fourth, teachers need to understand how children think about and learn mathematics. They need to learn how to listen to students, how to help their students share understanding, and how to assess students' understanding. Kennedy (1998) added that by learning how students learn subject matter, teachers also (a) learned the subject matter themselves, (b) learned how to recognize if and when a student learned, and (c) learned ways to teach the subject matter. Finally, teachers need to have opportunities to analyze and reflect upon their application of new knowledge.

Other research has focused on effective professional development processes that support teacher learning. The National Research Council [NRC] (1999), for example, described effective learning environments for teacher development that are centered on learning, knowledge, assessment, and community. These types of learning-centered environments consider the background knowledge and existing skills of teachers and use these as a foundation to build new understanding. Additionally, teacher development that is knowledge-centered provides opportunities for teachers to learn in ways that guide their thinking toward deeper understanding and the ability to transfer that understanding to practice. Assessment-centered settings provide time for reflection, feedback and revision. Finally, collaborative teaching communities give teachers opportunities to work together and learn from one another.

Additionally, Huberman (1995) argued that dissonance-creating and dissonance-resolving activities need to be connected to the teachers' own students and contexts in professional development experiences. In other words, dissonance needs to be created between teachers' existing beliefs and practices and their experiences. This dissonance can be created through new knowledge and understanding. For example, a teacher who experiences disequilibrium will attempt to restore balance by resolving dissonance through a change in beliefs or practice. Opportunities for teachers to resolve dissonance can be provided during teacher development experiences through discussion, reading, writing, and other activities that promote revision of their thinking (Loucks-Horsley & Matsumoto, 1999). Huberman further adds that ways need to be provided for teachers to develop a repertoire for practice consistent with new understanding.

Finally, Loucks-Horsley, Stiles, and Hewson (1996) offer a synthesis of *Principles and Standards* for professional development. They noted a great deal of consensus on the value of teacher learning experiences based on models of how teachers ought to teach their own students. Among these principles are active engagement, learning over time, and the opportunity to apply what was learned in the teacher's own classroom. These principles, along with an understanding of teacher efficacy, form a framework from which teacher change can be explored in relation to educational reform.

Recent studies have been conducted on a number of alternative forms of professional development including teamed action research (Burbank & Kauchak, 2003), communities of practice (Foulger, 2005), lesson study (Chokshi & Fernandez, 2005; Fernandez, 2002), and study groups (Jenlink & Kinnucan-Welsch, 2001). Teamed action research pairs a mentor with a novice in conducting an action research project. Both members of the team develop as professionals. The model designed to develop communities of practice focuses on collaboration of a group of teachers on common content while being directed by a professional developer. The developer teaches specific content and acts as a constant support to each of the teachers as they integrate their knowledge. Lesson study is a method of professional development adopted from the Japanese; it follows a structured process to improve lesson instruction. A group of teachers focuses on a common goal in a given content area. They then work collaboratively planning, teaching, observing, revising, and reteaching a small number of lessons. It allows teachers to build a professional knowledge base and connect policy to practice (Chokshi & Fernandez, 2005). Finally, study groups center on teachers working together on a common topic who are led by a facilitator. The benefits of this type of professional development are that the teachers have choice about the direction of their development and they take ownership for their own professional development as teachers. In addition, Jenlink and Kinnucan-Welsch (2001) found that teacher confidence increased. These benefits make study groups an important alternative professional development approach to consider when attempting to influence teacher efficacy.

Teacher Efficacy in Relation to Educational Reform and Teacher Development

A direct relationship between a teacher's personal teaching efficacy and his or her sense of personal capability of adapting to change has been identified (DeMesquita & Drake, 1994; Fullan, 1991; Stein & Wang, 1988; Swars, 2005). Indeed, research suggests that teachers with high efficacy are more willing and likely to implement innovative practices, while those who express low self-efficacy show less receptivity to new ways of teaching (Guskey, 1988). Too, positive feelings of efficacy may allow teachers to approach change with a sense of confidence; they are more willing to take risks and are more likely to persevere with implementation efforts when difficulties arise (Ross, 1994).

However, given the number of educational reforms and the responsibility of teachers for implementation, it is possible for teachers to view the reform measures as beneficial (general teaching efficacy) and yet feel anxious about their own ability to enact change, or even incapable of making all the necessary changes required of them (personal teaching efficacy). There is also some evidence to suggest that in attempting to enact change in their practice, many teachers experience increased levels of stress along with lower self-efficacy (DeMesquita & Drake, 1994). In light of this understanding, researchers have sought means to raise low teacher efficacy beliefs and sustain high teacher efficacy beliefs in order to facilitate the implementation of educational reforms (DeMesquita & Drake, 1994; Huinker & Madison, 1997; Ross, 1994; Stein & Wang, 1988; Swars, 2005; Weasmer & Woods, 1998).

Building on a foundation of research that has investigated possible relationships between teacher self-efficacy and a willingness to implement innovative practices, studies have recently turned to examining teacher development strategies that may strengthen teacher efficacy and, in turn, increase teachers' motivation to implement innovative reforms. Some of this research suggests that while self-efficacy is generally accepted as a positive motivator for teacher change, there are conditions under which too much self-confidence can become a hindrance to teacher change (Bandura, 1986; Huberman, 1995; Settlage, Southerland, & Smith, in review). For instance, Settlage, Southerland, and Smith (in review) studied the effects of science methods courses on the self-efficacy of preservice science teachers in relation to teaching diverse populations. They found no significant increase in personal science teaching efficacy and reasoned that this lack of increase could have been due to the factor that these preservice teachers entered the program with a high sense of science teaching efficacy even though they lacked experience and knowledge. In this case, the authors suggested that such feelings of high teaching efficacy may be a deterrent to a desire to change practice and, hence, a hindrance to professional development and educational reform. Along with Wheatley (2002), Settlage and his colleagues suggested that although elevating teacher efficacy is a worthy undertaking, a measure of self-doubt might well be an important mechanism for motivating teacher change. Loucks-Horsley and Matsumoto (1999) agreed that one way to maintain that essential component of quality professional development is to create a dissonance between teachers' existing beliefs and their experience. In doing so, an imbalance in the equilibrium between beliefs and practice is created, thus causing teachers to seek change in order to reestablish balance.

Although researchers need to be aware of the difficulties caused by an inflated sense of self-efficacy (Bandura, 1986), a more common obstacle to reform seems to be low self-efficacy. A number of studies of preservice and practicing teachers have examined this line of reasoning. For instance, a study of preservice teachers conducted by Huinker and Madison (1997) also used methods courses (elementary mathematics and science) that included teaching strategies specifically designed to positively influence self-efficacy. The courses were designed with an emphasis on Bandura's (1986) four sources of information affecting self-efficacy: (a) positive performance attainments, (b) vicarious experiences, (c) verbal persuasion, and (d) physiological states. Bandura asserted that teachers must weigh and integrate information from these sources in the formation of efficacy beliefs. The conclusions drawn by Huinker and Madison (1997) were that methods courses, combined with vicarious experiences, verbal persuasion, and fieldwork experiences contributed to preparing efficacious teachers of mathematics and science.

Other studies have examined teachers' efficacy in light of authentic classroom application of their new knowledge and understanding. For instance, Ross (1994) conducted a study in which teacher efficacy of practicing teachers was measured three times during an eight-month inservice program that presented cooperative learning techniques. Findings suggested that teachers' use of knowledge gained through inservice, rather than mere exposure to knowledge, contributed to a change in teacher outcome expectancy (general teaching efficacy). However, teachers were not convinced that they personally could reach students. As a result, Ross proposed that more powerful teacher development treatments be used to influence personal teaching-efficacy. For example, successful application experiences, supportive feedback, and collaboration should be included simultaneously with the implementation of new teaching ideas.

Stein and Wang (1988) also studied the relationship between teachers' successful implementation of innovative programs and their perceptions of teacher self-efficacy. Their findings supported the notion that a positive relationship exists between teachers' successful implementation of innovative programs and their perceptions of self-efficacy and their perceived value of the program. They also concluded that a cyclic relationship exists between learning, self-efficacy, and motivation. In brief, successful experiences in learning will enhance feelings of self-efficacy. Positive self-efficacy will then cultivate motivation to achieve, which, in turn, will influence future actions and learning. Thus, for teacher development efforts concerned with change, theses researchers recommend two important design features: (a) teacher development programs should include ways to foster teachers' interest in and commitment to program changes and utilization of innovations, and (b) provisions need to be made for continued support for utilization of the knowledge and skills required for successful implementation of innovations.

In summary, a teacher's sense of general and personal self-efficacy, which can potentially be influenced through teacher development programs, has been identified as a significant indicator of the teacher's willingness to implement educational reform (Guskey, 1988; 2000; Swars, 2005). In consideration of this finding, Ross (1994) suggests that it is vital that research continues to examine innovative teacher development programs that are tailored to foster positive teacher efficacy in relation to the implementation of innovations in the classroom. Ross added that these studies should move away from rigorous analytic techniques of large samples to a qualitative approach that would provide rich data within different contexts such as class size, grade, subject area, and student engagement. It has also been recommended that these programs: (a) incorporate the utilization of innovative practices along with skills and knowledge development (Guskey, 1988; Korthagen & Kessels, 1999; Stein & Wang, 1988); (b) provide opportunities for verbal encouragement and modeling through collaboration (DeMesquita & Drake, 1994; Foulger, 2005; Garet, et al., 2001; Ross, 1994), and feedback (Garet, et al., 2001; Ross, 1994; Steing & Wang, 1988); (c) maintain substantial, continuing, long-term support (Glazer & Hannafin, 2006; Stein & Wang, 1988); and (d) create dissonance between teachers' existing beliefs and their experience (Foulger, 2005; Korthagen & Kessels, 1999; Horsley & Matsumoto, 1999; Wheatley, 2002). Such research will add clarification and verification to the growing body of literature examining the interrelated workings of teacher efficacy, teacher development, and educational reform.

Conclusion

There is a growing body of research on the nature of change in teacher efficacy beliefs through teacher development as it occurs in the context of the current mathematics reform movement. However, gaps in research remain which may be filled by this study of a small collaborative group of teachers. The bulk of this research project was conducted from the perspective of a researcher examining the teaching efficacy of participants involved in implementing mathematics reform. The design of this study, however, allows the participant researcher to examine teacher efficacy more closely from the perspective of the teachers themselves. As such, this study plays an important role in deepening our understanding of teacher efficacy in relation to reform as it adds to the body of teacher change and professional development research. It has influenced my future decisions concerning the design of personal and faculty teacher development practices and may serve as a model for other practicing teachers who wish to engage in an alternative teacher development practice that differs from more traditional, short-term professional development experiences.

The purpose of this study was to examine the experiences of a small, collaborative group of teachers who are in the process of implementing innovative instructional mathematics practices. Additionally, I aimed to describe how that group evolved, investigate possible challenges and benefits of a professional development study group, and measure the possible changes in mathematics teaching efficacy over time.

CHAPTER 3

METHODOLOGY

This case study, which was conducted over a six-month period of time, had three purposes. First, this research explored the experiences of a small, collaborative group of elementary teachers as they strove to enact change in their mathematics instruction based on current reform. Second, this study examined changes in individual participants' mathematics teaching efficacy in relation to the study and implementation of *Standards*-based mathematics instruction throughout the group's journey. And third, the project explored this type of teacher involvement as a possible alternative to traditional teacher professional development. The specific research questions that guided this study were:

1. How does a collaborative group of teachers working together to improve *Standards*-based mathematics instruction evolve? What critical incidents denote the group's evolution? What issues obstruct or facilitate the group's development and interaction as it evolves?
2. Within the context of the current mathematics reform movement, how will the personal and general teaching efficacy beliefs of individuals toward *Standards*-based mathematics instruction within a small group of elementary teachers change over the course of six months as they are engaged in a professional development process designed to be supportive?

Design

Case study methodology, which provides a detailed account and analysis of an individual or a group in its natural context (Stake, 1988; Verma & Mallick, 1999), was the design of this study. A case study can be defined as a bounded system (Stake, 1995;

Yin, 1994) or a "set of interrelated elements that form an organized whole" (Johnson & Christensen, 2000, p. 327). As such, it relies on multiple sources of evidence (Yin, 1994) and involves an in depth analysis and an evolutionary description of the system and the interrelationships of the elements within it (Verma & Mallick, 1999). As Bullough and Baughman (1997) explained, "good case studies illuminate both experience and context; they help readers see anew what may otherwise be taken for granted" (p. 11). In summary, case study is a comprehensive method of research that examines a bounded system in context. It uses data collected from a variety of sources and provides an indepth analysis in order to describe, understand, and explain the interrelations of the system.

Several benefits of case study research methodology made it particularly suited to this study of a bounded system involving a small, collaborative group of teachers engaged in the study of *Standards*-based mathematics. First, the contextual nature of case study had practical application to this study; it allowed the researcher to be involved as a participant of the group. This study also sought to understand and describe 'how' the group developed in its natural environment and 'how' teacher efficacy changed in that context. Yin (1994) suggested that case studies have a unique advantage in situations in which "a 'how' or 'why' question is being asked about a contemporary set of events over which the investigator has little or no control" (p. 9). This characteristic allows the researcher to participate in the study, to deal with a full variety of data sources that are needed to reveal the nature of the system (Yin, 1994), and to analyze the wealth of interacting factors that have produced the entity's uniqueness (Murray, 1998). In addition, Yin suggested that case studies "can be based on any mix of quantitative and qualitative evidence (p. 14). This advantage allows the researcher to examine a variety of evidence through constant comparative methods and to evaluate all possible outcomes. Another benefit is that case studies can contribute to the clarification or expansion of current theory. Once more, this benefit made case study a good match for this study, which investigated teacher development in relation to teacher efficacy. Finally, a case study provides a methodological format that other researchers may want to adopt to generate new hypotheses or formulate questions that in turn, can be used to conduct their own investigations. In summary, case study provided a methodology rich in the elements that made it particularly suited to the needs of this study.

Researcher Stance

As noted previously, and in accordance with case study methodology (Yin, 1994), I acted as both participant-researcher and group leader. My qualifications for being the instructor for the group included: (a) teaching *Investigations in Number, Data, and Space* (TERC [Teacher Education Research Center], 1998) in my classroom (a curriculum widely used in my school district), (b) attending specialized TERC [Teacher Education Research Center] training, (c) acting as mathematics specialist for my school for 2 years, including facilitating faculty mathematics development, (d) teaching district mathematics inservice classes related to *Standards*-based mathematics, and (e) studying research related to the *Standards* personally, and (f) attending 6 credit hours of graduate level courses offered to teachers at a local university. The content of these courses consisted of activities designed to help me examine my own mathematical thinking, investigate the mathematical thinking of children, and practice inquiry based mathematics in my own classroom.

Important to note are my beliefs about how children learn. These beliefs are grounded in socioconstructivist cognitive theory. I believe children construct knowledge from authentic experiences, social interaction, and guided instruction from a knowledgeable teacher. This notion, coupled with my experiences of implementing *Standards*-based mathematics instruction in my classroom, has led me to develop a positive bias toward the effectiveness of *Standards*-based instruction.

Procedure

The collaborative Professional Development Study Group [PDSG], which was named, organized, and developed for this study by the researcher, was based on the prior work of other researchers. First, I drew upon the study of the development of a support group by Dickinson, Burns, Hagen, and Locker (1997) as described in the following paragraph. Second, consideration was given to the characteristics of quality teacher development experiences presented by Loucks-Horsley and Matsumoto (1999) and others as described in the review of literature. Finally, the tenets affecting the formation of teacher efficacy beliefs as outlined in Bandura's Social Cognitive Theory (1986) were considered in the design of the course content and participants' experiences. In the remainder of this section, I will elaborate on how the research outlined above (Bandura, 1986; Dickenson, et al., 1997; Loucks-Horsley and Matsumoto, 1999) influenced the design of the study's context.

Dickinson, Burns, Hagen, and Locker (1997) described their journey as a support group toward the improvement of their science instruction and science-teaching efficacy. They stated two objectives for their group: (a) developing of a collaborative teacher support group, and (b) increasing content and pedagogical knowledge. In order to accomplish these goals, they met together frequently to share ideas and experiences, attend courses, and develop assessment strategies. As with Dickinson and her colleagues, a collaborative group was formed for the current study that consisted of teachers who wanted to become more confident and competent in their mathematics instruction through increased content knowledge and pedagogical content knowledge (see Shulman, 1987). Within the context of the group an alternative form of professional development was examined. The group collaborated about *Standards*-based mathematics during the monthly meetings. The meetings consisted of three separate parts. At the beginning of the meeting the participants shared their experiences, questions, and concerns. Next, they engaged in *Standards*-based mathematics lessons. Finally, the members of the group reflected upon new mathematics knowledge and discussed ways in which they could implement it in their classrooms.

The specific curriculum materials for *Standards*-based mathematics study consisted of current literature dealing with the *Principles and Standards* (NCTM, 2003) and lessons taken from the following resources: (a) *Children's Mathematics: Cognitively Guided Instruction* [CGI] (Carpenter, Fennema, Franke, Levi, & Empson, 1999), (b) *Relearning to Teach Arithmetic: Addition and Subtraction* [RTAAS] (Russell, 1998a), (c) *Relearning to Teach Arithmetic: Multiplication and Division* [RTAMD] (Russell, 1998b), and (d) *Developing Mathematical Ideas: Numbers and Operations* [DMI] (Shifter, Bastable, & Russell, 1999a). These three resources provided a framework for understanding children's thinking about mathematics and how their mathematical understanding develops from the perspective of *Standards*-based mathematics instruction. The curricula are also reflective of a socioconstructivist method of teaching and learning. In addition, they provided opportunities and support for teachers to examine their own thinking about mathematics. Materials from these sources were chosen to meet the evolving needs of the group through attention to feedback from the participants.

Participants attended the bi-weekly or monthly PDSG meetings, applied new understandings in their implementation of *Investigations in Number, Data, and Space* [hereafter referred to as *Investigations*] (TERC, 1998) or *Connected Mathematics Grade 6* [*CMP*] (Lappan, Fey, Fitzgerald, Friel, & Phillips, 2004) in their classroom, kept meeting notes, and participated in other forms of data collection such as personal history timelines and interviews. In addition, as a member of the collaborative professional development group, I acted as both participant-researcher and group leader. In this capacity, I prepared lessons and agendas for the meetings, modeled *Standards*-based mathematics instruction, and kept a reflection journal.

Investigations (TERC, 1998) and *CMP* (Lappan, et al., 2004) are respectively K-5th and 6th grade mathematics curricula adopted by the district. Both curricula were designed to meet the instructional goals of the *Standards* by offering students meaningful problems that can be explored in depth. Through these curricula, students (a) work as a class, with partners, in small groups, and independently to come to an understanding of mathematical concepts, (b) invent their own strategies and build on their own and their peers' understanding to attain fluency in mathematics, and (c) explore mathematics in their own environments, both at school and at home, with the goal that the mathematics becomes relevant to each student's background and needs.

The lesson content of study for the group contained elements prescribed by Loucks-Horsley and Matsumoto (1999) as important to include in facilitating quality teacher development. Those elements give attention to: (a) knowledge, skills, and beliefs about content; (b) understanding of student thinking and learning; and (c) pedagogical content knowledge. The elements recommended by researchers that create effective professional development contexts were also included in the nature of the study group. As suggested by Loucks-Horsley and Matsumoto (1999), these elements include collegiality, collaboration, experimentation, nurturing professional practice, professional development decisions that are aligned with student learning goals, and strong leadership. Other aspects of context suggested in the literature for teacher development were also attended to as follows: (a) the span of the study provided long-term support (Stein & Wang, 1998); (b) timely feedback (Ross, 1994) was given through frequent communication, modeling, and group discussions which provided opportunities for narrative self-reflection (Van Manen, 1994); (c) new ways to think about mathematics which created dissonance between beliefs and experience were offered (Settlage, Southerland, & Smith, in review; Wheatley, 2002); and (d) Bandura's (1986) sources for development of teacher efficacy as described in the following paragraph were utilized to enhance mathematics teaching efficacy (Guskey, 1988).

Bandura (1986) articulated four elements instrumental in the formation of efficacy beliefs, each of which was taken into account in this study. First, successful performance attainments occurred both during study group instruction as the teachers explored and applied their own mathematical understanding and in their classroom as they applied new knowledge to classroom instruction. Successful performance attainments can be defined as having personal successful experiences. Second, vicarious experiences were provided by observing modeling of instructor, viewing and analyzing case studies from videotapes, and sharing experiences during collaboration and other conversations. Third, verbal persuasion or encouragement was given as I expressed confidence in their abilities to implement reform changes. The nature of collegiality also created an environment where verbal encouragement from all members of the group flourished. Finally, observable physiological states e. g., physical responses such as smiling were noted as a natural result of the employment of the other three sources listed above.

Participants

Six teachers were purposefully selected from a large school district in the Intermountain West to join with me in collaborative support/study group. The selection process came about through discussions with colleagues about the nature of my study. Three criteria were important in determining participation in this study. First, the participants needed to express a desire to change (Fullan, 1993); more specifically, teachers needed to be interested in improving their personal implementation and instruction of *Standards*-based mathematics and willing to examine their beliefs in the process. Second, because collaboration is shown to be more effective when the participants are focused on the same subject matter and similar grade levels (Riordan & da Costa, 1998), the participants were elementary teachers in the process of implementing *Investigations* (TERC, 1998) or *CMP* (Lappan, et al., 2004) curriculum (both described previously). Third, because we met frequently, proximity to my school was necessary to facilitate ease in collaboration. Through information acquired in personal conversations, six teachers were invited to participate.

Participants were compensated for their study group time by the school district as follows:

1. One lane change credit was offered to each participant. These credits are used to meet the requirements for increased salaries.
2. Participants were not required to pay district inservice fees to record their professional development credit.
3. Participants also received any personal and professional benefits that are an inherent part of the study. These benefits included, but were not limited to, specific instruction on content and pedagogical content knowledge during group meetings, collegial support, timely feedback, and personal reflection opportunities.

Participants were protected through the use of pseudonyms throughout the research, and will continue to be so for any ensuing publications and presentations. Also, the Institutional Review Board of Brigham Young University reviewed and approved research procedures for this study before its initiation, and each participant signed an informed consent form (see Appendix A).

This study did not directly involve the students from the classrooms of the participants. However, examples of student responses were discussed and used during collaboration. When such a situation occurred in the group, precautions were taken to protect student identity through the use of pseudonyms or speaking of students in general terms.

Data Collection

Because multiple data sources are a vital feature of case study (Stake, 1995; Yin, 1994), I collected data from several types for this study including (a) personal mathematics critical events timelines (see Appendix B), (b) interviews, (c) reflective journals, (d) exit cards, and (e) teacher produced artifacts. By doing so, I was able to provide a rich description of the context and interactions within the group as well as add validity to the results. Validity was addressed through the convergence of data in a triangulating fashion (Johnson & Christensen, 2005; Stake, 1995; Yin, 1994).

Although the Mathematics Teaching Efficacy Belief Instrument [MTEBI] (Enochs, Smith, & Huinker, 2000) was developed to measure the efficacy beliefs of teachers of mathematics, it was not used in this study because of the small number of participants (N=6).

Critical Mathematics Events Timeline

Beliefs about teaching are formed early and are well established by the time an individual reaches college (Pajares, 1992). These beliefs are at the core of becoming a teacher (Lortie, 1975). Therefore, personal mathematics critical histories were useful to both the participants and me in helping us understand the formation of our mathematics teaching efficacy beliefs. They were also useful in guiding the selection of instructional materials. The participants were given a prompt (see Appendix B) asking them to complete a critical history timeline, to be submitted to me before the first group meeting.

Interviews

According to Yin (1994), interviews are one of the most important sources of information for case study. They focus directly on the participants by providing them with the opportunity to express their insights and opinions first hand. The use of interviews conveys to the respondents that the researcher values their opinions (Murray, 1998). Interviews were conducted three times during the research as deemed necessary for checking teacher efficacy changes and clarifying data. I used a response-guided strategy (Murray, 1998) to develop questions. In essence, I began with a prepared, open-ended question and then created follow-up questions based on the respondent's answer. An initial interview was conducted at the beginning of the study to determine participants' beliefs toward an understanding of *Standards*-based mathematics as well as their perceptions of their abilities to implement it in the classroom (see Appendix C). For any succeeding interviews, previous data collection was considered in formulating the questions. A second interview was conducted midway through the group study to assess any progress in understanding or changes in mathematics teaching self-efficacy beliefs (see Appendix D). A final interview was conducted at the end of the experience to examine understanding, changes in mathematics teaching self-efficacy, and participants' overall thoughts about the experience (see Appendix D). The interviews were conducted individually to ensure privacy and were audiotaped and later transcribed.

Journals

The participants and I kept reflective journals as a fourth source of information. A research journal is a good tool for piecing the chronology of the study together (Johnson & Christensen, 2005). My journal was used to record a variety of data including feelings, impressions, reflections, participant comments, quotes, and ongoing analysis. The participant journals were used during each group meeting to record learning, thoughts, feelings, questions, insights, and the like. The journals helped us put our thoughts into words and better understand our experience together. Although participants may have chosen to use their journals at other times as well, the opportunity to share information from journals was given during each group meeting.

Exit Cards

At the end of each study group meeting, each participant filled out exit cards. They were asked to describe what they learned, what they would like to apply in their classroom, what questions remained unanswered, what they had experienced in their classrooms, and how they felt about implementing new understanding in their classroom.

Artifacts

As a final data source, I collected artifacts such as lesson plans, videotapes, and readings used during group meetings. Artifacts were useful in verifying and enhancing evidence from other sources (Yin, 1994). The lesson materials and readings that I collected, along with participants' responses to those sources, were useful in helping me understand some tools that were valuable in improving teachers' confidence in implementing *Standard*-based mathematics.

Data Analysis

Qualitative analysis was based on the principles of grounded theory, which was originally developed by Glaser and Strauss (1967) and later described by Strauss and Corbin (1998). Strauss and Corbin defined grounded theory as "theory that was derived from data, systematically gathered and analyzed through the research process" (p. 12). Grounded theory, also referred to as a constant comparative method of analysis, allows a researcher to analyze data inductively, using both critical and creative thinking and arrive at a theory. Therefore, this approach offered me an opportunity to select a case in which a large amount of data would be collected and analyzed. In addition, it provided a systematic means of analysis in which theory can be developed or existing theory may be elaborated. It also provided a way to integrate analysis of data from various sources, making it a good fit for the study.

With grounded theory, data collection and data analysis are interactive (Strauss & Corbin, 1998). Therefore, I began analyzing data immediately upon collecting it. This method of analysis consists of three types of coding procedures. The first procedure is open coding, which involved analyzing data to identify concepts, their properties, and their dimensions. During open coding, I examined initial data, labeled parts, and identified commonalities that allowed me to sort data into categories. Axial coding, which systematically develops and relates categories to subcategories, was then used. Axial coding involved several basic tasks, including laying out and refining the dimensions of categories and subcategories, stating how categories and subcategories are related to each other, and searching for clues that might link major categories together (Strauss & Corbin, 1998). New data, which were collected during axial coding, were submitted to open coding before applying axial coding. Finally, I used selective coding to integrate the categories and identify a core category and refine theory.

An explanation of the notations used to cite data sources in chapters four and five is given here to help the reader identify those sources. Each notation begins with the pseudonym initial of the participant from whom the source was obtained as follows: (a) S for Scott, (b) A for Alvin, (c) L for Lexi, (d) C for Claire, (e) Ka for Kathy, (f) Ke for Kendra, and (g) H for Hundley. This designation is then followed by the type of data source: (a) I for interview, (b) E for exit card, and (c) J for journal. Finally, a number is given indicating the number of the interview or exit card or the page number of my journal. For example, a reference from Kathy's second interview would be noted KaI2; a reference form Claire's third exit card would be noted CE3; a reference from the ninth page of my journal would be noted HJ9.

In order to provide a more accurate picture of my study and further triangulate data, I employed member checking (Stake, 1995). I asked the members of the study group to discuss parts of my initial thesis analysis to clarify interpretation. This process allowed me to give a complete and accurate picture of the group study. I also consulted with my chair, Dr. Leigh Smith, to ensure that my biases had been addressed and that I had considered all the variables influencing my conclusions. Doing so helped me to present a more faithful accounting of my study.

Limitations

The scope of my research was limited in two areas. First, the participant-selection criteria eliminated teachers who were resistant to change as well as those who were teaching traditional mathematics. However, considering that mandated change is seldom effective in implementing innovative instruction (Fullan, 1993), the desire and opportunity to implement *Standards*-based mathematics and a willingness to change in order to do so was essential in addressing the concerns of this study. Second, there may have been a natural bias on my part as a participant-researcher. In my role as school mathematics specialist and as a teacher who believes in a constructivist approach to teaching, I recognized a positive, personal bias toward the use the *Standards.* In order to minimize the influence of bias on my study, I reported data as objectively as possible. I also frequently and consistently took time to seek for confirming or disconfirming evidence, as well as personal bias in my report data and analysis. As added measures, I triangulated data from a variety of sources, enlisted the aid of participants to do member checking, and sought the objective view of my graduate committee.

CHAPTER 4

RESULTS

A description of the PDSG and its participants is essential to understanding the dynamic changes that occurred during the course of this study. The participants were recruited from among colleagues in two schools within the school district. As the researcher, I was interested in working with teachers who were interested in becoming more effective in using *Investigations* (TERC, 1998) and *CMP* (Lappan, et al., 2004) mathematics curricula and were willing to be involved with a group that would meet together often over the course of the school year. Kendra, Kathy, Scott, and Alvin (pseudonyms) were four teachers from my own school who expressed a desire to be a part of the group. Lexi, one of the other two members of the group, was a member of my grade level team the previous year, but had moved to a new school. However, she was still willing to be involved with the group and invited Claire, a colleague from her new school to come with her. A brief introduction to each participant follows.

Description of Participants

Kendra is a young fourth grade teacher who has been teaching the *Investigations* (TERC, 1998) curriculum for three years. She was a student in traditional mathematics classrooms while growing up and felt very confident in her mathematical understanding. In college, she was introduced to *Standards*-based mathematics in her elementary mathematics methods courses. She had also had intermittent experiences in inservice classes that helped her prepare materials to teach the *Investigations* (TERC, 1998) curriculum. From these experiences she recognized the potential value that this type of instruction could have for her students. However, she was insecure with her own ability to implement effective instruction. She felt that her students were not becoming involved in effective classroom instruction or sufficient strategy sharing. She also felt that they were not making necessary connections to mathematics concepts. Thus she expressed a desire to know how to ask better questions and frame her lessons in a way that would produce better student involvement and learning.

Kathy is a part-time teacher in the sixth grade. She has come back to teaching while still raising a family. She had no experience as a student with *Standards*-based mathematics. Indeed, her first introduction to *CMP* (Lappan, et al., 2004) was in district workshops focused strictly on the sixth-grade curriculum. The workshops were frustrating for her because they provided a great deal of information about teaching *CMP* but allowed no time for relearning how to teach mathematics using this type of methodology. The workshops also neglected to help teachers gain an understanding of the potential benefits of *CMP*. So, Kathy felt they were a waste of time and that the only reason to teach *CMP* was because teachers were asked to do so in her school. She was grateful that her job-share teaching partner agreed to be responsible for mathematics instruction. However, she became interested in becoming a part of the group because of her relationship with me and because she worried that she would eventually work full-time and have to teach *CMP*. She expected that she would gain a better understanding of how to teach *Standards*-based mathematics from her participation in the PDSG.

Scott is an experienced teacher in the fourth grade and is currently working on a doctoral degree in literacy. He described himself as a “direct instruction” teacher. He is also very concerned about high stakes testing and likes to be in control of a very structured learning environment. He has taught bits and pieces of the *Investigations* (TERC, 1998) curriculum, but maintained a very expository instructional approach in his lessons. However, during his research in his graduate program he became interested in how children learn. As a result, he became more concerned about how to implement an inquiry approach in his classroom. Through a mutual graduate class, he learned of my study and expressed an interest in participating. Although he was not able to attend every group meeting, he came prepared and excited about the things that he was learning. He had a student teacher during the second half of the year and he was able to observe her using an inquiry-based approach to mathematics. Being able to see this type of instruction benefiting his students and being able to unpack his own understanding in the group gave him concrete understanding that helped him make changes in his own practice.

Alvin is an intern working as a resource teacher for children with special needs and teaches mathematics to small groups of upper-grade students in a self-contained classroom. At the beginning of the study, he was very confident in his ability to teach mathematics using any curriculum as long as he knew it himself. When he joined the faculty at my school, he found himself on unfamiliar ground with the vocabulary and methodology of *Standards*-based mathematics instruction. He worked with inclusion students in my classroom during reading and came to trust me as a teacher and colleague and later voiced his desire to be a part of the PDSG. He felt that as he learned the vocabulary and the concepts he was to teach he would be able to implement the *Investigations* (TERC, 1998) curriculum in his classroom. However, he expressed concern that this type of mathematics would not be beneficial to his special needs students because of their need for so much structure and repetition.

Lexi started her family and then came into teaching part time her first year. We became acquainted as we worked on the same fifth-grade team. She came with no personal experience with *Standards*-based mathematics. During her first year, she taught only science and writing. She then decided to work full-time teaching fourth grade at a different school where she encountered her first experience teaching mathematics. She attended a monthly support group that helped teachers prepare materials and identify the major mathematics emphasis of each *Investigations* (TERC, 1998) unit. She struggled, however, with implementing this type of mathematics instruction because she did not understand how to think about mathematics in new ways and was afraid to let her students explore their own thinking for fear she would not be able to understand their thinking. Additionally, as she experienced frustration in helping her own children with their *Investigations* homework because she did not know what the teacher wanted, she turned to her husband, who, she claimed, just naturally thought that way. She wanted to be a part of the PDSG so that she could learn to think about mathematics in new ways. She felt in doing so she would be more comfortable in teaching her students and allowing them to become more engaged and in charge of their mathematics learning.

At the beginning of this study, Claire was in her first year of teaching. She had been very confident in her understanding of mathematics as a student, had worked very hard to get good grades in mathematics, and had found that if she could memorize the steps and get the right answers she was successful. In college, she was introduced to inquiry-based mathematics instruction. She found it very frustrating because she never knew if she was doing the problem solving “correctly”, and the instructor would respond to her questioning with more questions. She completed her student teaching in a school district that used a traditional approach to teaching mathematics and allowed her to use her early knowledge and experience to teach mathematics. As a result of her negative experiences with *Standards*-based mathematics, she was nervous about her ability to implement *Investigations* (TERC, 1998) successfully in her classroom. She expressed a desire to know more about it and to see how other teachers taught it. She also explained that she followed the teacher’s manual very closely and did all of the activities, but that she was afraid to be spontaneous and was stuck to the script in the book. She felt much more comfortable when she could just teach the mathematics concepts directly and answer the students’ questions. With the busy schedule of a young single woman she was hesitant to commit to the group, but wanted to at least give it a try.

As a fifth-grade teacher and the mathematics specialist in my school, I became interested in understanding why some teachers were so hesitant to implement the *Investigations* (TERC, 1998) curriculum. My fifth-grade team was interested in effective innovations in the classroom and adopted the *Investigations* curriculum a year before the rest of our school. I found the inquiry-based instruction in line with my own personal beliefs and took graduate-level college courses to help me better understand my own mathematical thinking as well as the mathematical thinking of my students. As I participated in these courses I gained confidence in my own ability to think more effectively and efficiently about mathematics and as a result became more confident in mathematics instruction in my own classroom. At the beginning of the study I had taught *Investigations* in my classroom for 4 years, had taught three week-long in-service classes for the district based on *Developing Mathematical Ideas* [DMI] (Shifter, Bastable, & Russell, 1999a; 1999b) and *Relearning to Teach Arithmetic* (Russell, 1998a; 1998b) course manuals. I had also served as the school mathematics specialist for 2 years, during which time I made several presentations about *Investigations* during professional development meetings.

Description of the Professional Development Study Group

Over the course of the study the context and dynamics of the group changed. In the beginning, I had outlined a curriculum for lessons to be taught based solely on *Relearning to Teach Arithmetic* (Russell, 1998a; 1998b). These curricula emphasized children's thinking about basic operations. However, my intent was that the lessons would be flexible during the process of group development and the members would be able to express their questions and concerns through discussion, exit-cards, and interviews. My other hope was that I would be able to lead the group from their initial expectations of my role as a teacher-leader to a more facilitative role as teacher-participant.

The format of each meeting basically consisted of three components. First, we would have a discussion about what was currently going on in their classrooms. I would ask questions about their successes and concerns and encourage them to share ideas and ask questions. The second component was a mathematics lesson based on basic mathematics operations that I presented. I was prepared to spend 2 weeks each on addition, subtraction, multiplication, and division. I planned the lessons using inquiry-based methodology, providing authentic mathematics story situations, sharing one another's strategies, viewing videotapes of students solving the same problems, and unpacking the students' thinking. Finally, at the end of each meeting we would spend a few minutes in a follow-up debriefing. We shared what we had learned, what the participants wanted to apply in their classrooms, and what questions they still had. Information would then be recorded on exit cards.

During the first two meetings, participants were hesitant to ask questions, share their ideas and thinking, or interact with each other. They looked to me to answer their questions, address their concerns, direct the discussions, and supply all knowledge. However, I was desirous that the locus of control shift from me to the group as a whole. Therefore, in response to their behavior, I made conscientious efforts to redirect participant questions and concerns to the group before supplying information during the discussions and follow-up portion of the meetings. I took note of their needs and paid particular attention to their exit cards when they expressed what they would like to see addressed in succeeding group meetings. I then found research articles and readings that addressed their concerns and altered my lesson plans accordingly.

During subsequent meetings these changes in my facilitation brought about the evolution of the group. As it became clear to the participants that I would look to them first to answer each other's questions and that I respected them as professionals they began to see each other this way and turn to one another for support. Lexi was the first to initiate the change in locus of control. During the second meeting, when Kendra expressed discouragement in helping her children understand rounding numbers, I asked the group what things they had done in their classroom that worked well for each of them. Lexi volunteered a strategy that she had successfully used with her students. This initial volunteering of information opened the way for others to feel comfortable sharing as well. They began to ask questions that were directed to the group instead of to me. They found that others in the group were in the same state of not knowing. This knowledge allowed them to open up and share their concerns with each other. As Claire (H12) expressed, "I love coming and see[ing] others having the same concerns." This statement from my reflection journal after the third meeting describes the change:

> I felt that the group came together more today. They seemed more invested in the lesson. They felt freer to ask questions and express concerns. They were more engaged in their own personal learning. There was an air of excitement in the classroom. I had fun as a facilitator. [Kendra's] exit card comments about what she would like to see addressed at our next meeting were, "even more sharing as a class strategy ideas. It was great." (HJ7)

Kathy was the least confident in sharing her mathematical thinking with the group. A description of her transformation is indicative of the groups' transformation as a whole: Initially, when it came time to share strategies, Kathy was happy to sit quietly and admire the work of the others. When I invited her to share her thinking, she said that she only knew how to do the standard algorithm. I asked her to share anyway, which she did reluctantly. Then I asked the group to compare Kathy's strategy with others on the board and make connections between the different parts of the problems. Unpacking Kathy's strategy by looking at the other strategies became the springboard for discussions about understanding why standard algorithms worked. The participants then began to realize how they could incorporate that knowledge in helping their students understand a standard algorithm when another student in the class used it as his or her strategy. Kathy began to feel more comfortable trying out the strategies of other participants and working with partners. She began to examine her lack of deep understanding of place value and asking group members to teach her about their thinking. Eventually, she became excited about her new knowledge and was eager to apply it in her own classroom. Toward the end of the study, she commented on how important it had been for her to feel that her thinking was "fabulous" (KaI3) and contributed to the group. It gave her the confidence to teach in new ways in her own classroom.

As the group evolved, I also became more comfortable in my role as a facilitator. The participants responded well to the trust I placed in them as professionals and as learners. As a result, I was able to make a shift in my responsibilities for group learning. I became more relaxed in my instruction and moved away from the scripted lessons in the *Relearning to Teach Arithmetic* manuals (Russell, 1998a; 1998b) and constructed lessons based on my own experiences and lessons I had had in my college courses. I also used resources from other books and teachers in the school to help me prepare lessons that were based upon the teachers needs. We quickly covered the four basic operations using whole numbers and moved on to place value, fractions, and decimals. After the fifth meeting I wrote as follows:

> The lessons are going well. I feel comfortable in following the flow of the group even when it veers from the intended concepts I have planned [to teach]. The participants are eager to learn more and seem to be happy to attend. (HJ13)

The sixth meeting seemed to be the pivotal one for a more complete transformation of the group's thinking of the PDSG as a class to the group as a collaborative effort, as three critical events occurred during this meeting. One critical event illustrates the significant shift in the locus of control: As we were wrapping up the discussion portion of the meeting and I was ready to move on to the lesson, Lexi stopped me. She asked me to wait in order for the group to discuss another concern that she felt we had not adequately addressed. She did not hesitate to assume control of the group in order to meet their needs. A second event altered the content of the lessons. We had been viewing videotapes of children's thinking about operations. The participants expressed the feeling that a better use of their time was spent in actually doing the problem solving and sharing their own strategies with one another rather than watching the videos. Thus, we decided to abandon the tapes. Finally, during our follow-up discussion, several participants expressed the concern that although they had enough content knowledge, they still lacked a clear view of how to teach it. I asked the participants if they would be interested in watching me model mathematics instruction either with my students or theirs and they all responded positively. This led to setting up times with each teacher to facilitate a modeled lesson. They all commented on how useful those opportunities were for them.

The following description from my reflection journal sums up the final climate of the group:

> The group has overcome all inhibitions about asking questions. They no longer use phrases like, "This may sound really dumb, but . . .?" They also are working well together, sharing their strategies with one another without prompting form me. The discussion sessions are often initiated by one of the members now instead of me probing for information. And their questions are being directed to the group instead of to me. Group members will often share what is working for them in their classroom in support of those who might be struggling with something. (HJ17)

Findings

Findings from the present study are presented in three sections. The first section describes the development of the PDSG, the hindrances and contributors to group development, and the changes that were manifested in the dynamics of the group over time. The second section explicates the participants' evolving general efficacy beliefs toward *Standards*-based mathematics changes over time. Finally, the third section discusses the participants' responses concerning personal teaching efficacy changes toward the implementation of *Standards*-based mathematics in their classrooms.

Development of the Professional Development Study Group

As the group began to meet together, it quickly became clear that there were factors that positively and negatively impacted group development. In an examination of the factors involved in the development of the group itself, two factors were found to hold back the group's development: (a) time, and (b) small size of the group. On the other hand, three main factors were found that contributed to the group's development: (a) facilitator role, (b) flexible content that related to current needs in practice and, (c) growth of relationships within the group.

Time as a Hindrance to Group Development

Time was the main deterrent to group development. It was difficult for the teachers to take extra time to attend any type of professional development. Additionally, all of the participants were involved in other outside graduate and inservice courses. Alvin was finishing his special education certification and Scott was working in a doctoral program. Claire was in her first year of teaching and taking other inservice classes as well. Kathy and Lexi had children at home for whom they had to arrange childcare. Kendra was taking inservice classes as well as dealing with health issues. Indeed, as a facilitator-participant, I also found it difficult to find the time to keep up with course work for my Master's program, teach full-time, attend to family matters, and prepare lessons for the group. Alvin commented that it would have been better if the group could have met during the summer when life was less hectic (AI3). Lexi felt that she would like to continue with the PDSG for another year but that scheduling would be her only concern; she would have to work it into her already busy schedule (LI3).

Size of the Group as a Hindrance to Group Development

The other factor that minimally inhibited group development at times was the size of the group. Because of the personal and professional conflicts mentioned in the preceding paragraph, there was seldom a time when all group participants were in attendance at the group meetings. This created extra work for me as a facilitator. I would put together packets for those missing and plan additional times when I could meet with them personally to debrief them on the concepts that they had missed. Those in attendance also missed the input of those absent in our group discussions.

Factors Contributing to Group Development

Three factors that contributed to the development of the group were the, (a) role of the facilitator, (b) flexible content that related to current needs in practice and, (c) dynamic growth of relationships within the group. There were several sub-categories found relating to each of these main factors that will also be described in the following sections.

Role of facilitator. Four roles emerged as important in the positive growth of group development. The first was facilitator as expert or more knowledgeable other. This role was essential to the group's development. It was evident that there was a need for some member of the group to understand the content of the study at a deeper level and know how to help the group understand the mathematics content as well as how to teach it. As facilitator, I was able to assess the needs of the participants, prepare materials and goals for study, and provide instruction and modeling as components of each group meeting. I also became a sounding board for the participants, one whom they could come to as they encountered concerns or questions in their classroom instruction. Lexi expressed her confidence in me as the expert:

> You answer the questions. You know, we do the exit cards so we have a chance to write down things that we're concerned about or things that I'm frustrated with or question. And you always seem to come back with something to answer that or help with that. So I'm happy with how it's going. (LI2)

Claire added that the biggest impact on her as a teacher came from the lessons that I taught the group. She enjoyed the way the mathematics concepts were presented, applied, and discussed (CI2).

The second component of my role was that of coach and supporter. Scott described how he had felt controlled in other professional development settings. However, with this group he felt that his needs were met as a student because I acted as a coach who facilitated his learning rather than a lecturer telling him what he should be learning and doing (SI3). Kathy felt that my support and encouragement of each member of the group as a learner enabled all to overcome their feelings of inadequacy. She explained that in the beginning group members were afraid to ask questions for fear of appearing unintelligent. However, as I praised their thinking and encouraged sharing of responses that feeling dissipated and the group became comfortable in sharing their thoughts and concerns (KaI3).

Third, the facilitator's role as a model of mathematics instruction was a significant resource to the group. Many of the group members liked what they were learning about mathematical concepts but expressed concern about how to implement instruction in the classroom for their own students. As a result of their concerns, I began to focus their attention on the strategies that I used in instructing them. I also arranged times with each teacher to model an authentic lesson for her or him in my classroom or in her or his classroom. As each participant began to observe not only content but also pedagogy he or she expressed greater confidence in their own ability to implement mathematics instruction in their own classroom. Kathy commented as follows:

> I liked to watch you so we could repeat what we saw. I liked you teaching us as you would teach your own students. And that's what we could take away and do in our own classroom. And I also liked the way you had us work out problems ourselves and then we could see all the different strategies just like a real classroom. (KI3)

Lexi and Claire both expressed greater confidence in themselves as teachers after the classroom modeling experience. They explained that they felt freer to diverge from the scripted text and engage their students in greater participation (LI3; CI3). They also recognized *Standards*-based instructional practices that they were doing well and that helped them feel better about themselves as teachers (LI3; CI3).

Finally, it was expressed by members of the group that there was a need for someone to handle the organizational needs of the group. As facilitator, I assumed that role: organizing a schedule, communicating changes, and guiding group discussions and the content of study.

Enhanced content and pedagogical content knowledge. A significant factor contributing to group development was a focus on content that was pertinent to the participants' current instructional needs. All participants were in schools that were in the process of implementing a Standards-based mathematics program. Although the district had provided one or two day training workshops to support implementation, these workshops were insufficient in supplying the depth of understanding of mathematics concepts and instructional methods that would support successful implementation of the changes necessary to teach in a new way. The instructional content of the PDSG focused on new the ways of thinking about mathematics as well as instructional methods geared to create the type of inquiry environment that would allow students to think about mathematics in new ways. For example, Claire mentioned how the PDSG lessons on multiplication and division were very helpful because her class was doing a big unit on that (CI3). Lexi reported that her fraction instruction had been struggling until we focused on equivalent fractions in a PDSG meeting (LE4). The content instruction had given her the additional understanding of mathematics that she needed to support the students' understanding and have a successful experience in her class.

The flexibility of the content instruction given during the group meetings added to its value for the participants. As the group met and discussed their needs and concerns, the content instruction and discussions were modified to meet those needs. For instance, during a lesson on subtraction strategies participants made connections to multiplication and division questions with which they were currently dealing in their classrooms. The subtraction lesson was postponed in order to answer their questions (HJ4). This practice was a key in promoting the usefulness of the PDSG. Lexi explained, "I appreciate how flexible you were. . . . When we were asking questions or wondering about certain things, you were willing to wander away from what you had necessarily planned for that day . . . and address our concerns and questions." (LI3). Kathy added, "We go off the track and you answer [our] needs immediately. And [we] have immediate needs. . . . but you cover them and that's so essential" (KaI2).

Finally, a balance of disequilibrium and resolution based on participants' learning of mathematics concepts allowed them to become engaged and excited about their own thinking and to think in deeper ways. Most of the participants were having trouble helping their struggling students understand place value. As a result, I prepared an inquiry lesson using manipulatives to help the participants learn how to use base five. We spent sufficient time on modeling to allow them to discover their own questions and become confident in adding and subtracting using number sentences. Through their struggles in understanding a new place value system the participants were able to identify problem areas their own students were facing. Kendra explained that base five was tough for her. She appreciated being able to use the models and became excited to return to her class to work with her students on base ten concepts (KeE2). Alvin appreciated looking at simple problems more deeply. He explained as follows:

> Instead of hitting a lot of topics, we [would] hit one and go somewhat in depth. And I like going into depth. I've had enough of this shotgun mentality; I would like to do deep for a while. (AI3)

Later in the same interview he said as follows:

> I'm good at math, so I could always do it myself and tear it apart, but now it has some sense. Instead of [my] ability to do it, I could tear it apart and figure it out. I thought, "Oh, a good way to think about it is this, or a deeper way to think about it is this. And, if I want to get even deeper or more in depth we can do this. (AI3)

Comments made by the participants during group meetings revealed how they had become engaged in thinking about mathematics content in new ways. Comments like, "I never thought about it like that," or "Wow, that pattern is cool; I can use that with my students right now," were common responses as the participants discovered new ways of looking at basic mathematics (HJ17).

Growth of relationships. A number of factors contributed to the group's development of relationships. These factors were: (a) desire to learn and opportunities to share, (b) common needs and experiences of the participants, (c) participant diversity, (d) verbal praise, persuasion, and encouragement of the facilitator, (e) successful performance attainments during the lessons, (f) long-term involvement, and (g) small size of the group. These factors encouraged relationships to develop that enabled positive growth on the part of the participants. Because of these interrelated factors, a risk-free environment was cultivated in which participants felt both valued and validated. As trust grew they became more open in their communication with one another and more willing to share personal thinking about mathematics problems. Evidence also pointed to a shift in the locus of control from the sole responsibility of the facilitator to being more centered in the group as a whole. For example, in the beginning of study, some of the participants were worried that they would look stupid because they could not think in new ways and they had to deepen their understanding of basic mathematics. They hesitated to risk sharing their thinking and their concerns. At that point, they looked to me as the giver of all knowledge because doing so was safe. As they came to realize that the other participants, even the doctoral student, had the same needs, questions and frustrations, they commented on how that knowledge changed and enhanced their comfort level (LI2). Following are individual stories that illustrate how some of these factors worked together to bring about positive relationships within the group.

Claire's experience illustrates how several of these relationship factors combined to help her feel more comfortable as a participant in the group. In the beginning she did not want anyone to see her answers during the lesson (CI3). She was afraid that the other participants all knew what they were doing and she was the only one who did not know what she was talking about. At the same time, Claire had strong desires to be better equipped to help her students better understand mathematics (CI1). Consequently, during group lessons I encouraged her to share with Lexi, who taught at the same school as Claire and had similar concerns. As they shared with one another, they found valid strategies that helped the other participants understand how to compose and decompose numbers. Claire's strategies were clear, efficient, and often insightful. I praised her and encouraged her to explain her thinking to the others. The group began to try to solve other problems using one another's strategies. As a result, Claire began to feel validated in her current level of understanding and valued in her ability to contribute to the learning of the group. In her final interview she said as follows:

> In the beginning I didn't really want anybody to see my answers. I [thought], "I'm probably doing this wrong." But Lexi was there, so we would kind of share with each other but I didn't want anybody else to see. . . . And then towards the end I realized that everyone was still learning, so I felt more comfortable. I remember the very last [meeting]. I was talking to the guy next to me (Alvin) and he was sharing his strategy and I was confident that my strategy was the right way, but it ended up not being [right] actually. But he told me, so we were helping each other. So I think we got to be more comfortable and just more willing to share our ideas and our strategies and being confident in those even when we were wrong [laughs]. (CI3)

Scott's experiences reveal how the common needs and the small size of the group helped him to grow, relationships to develop, and communication to be more open. "I thought it was just nice to have a support group. We're all trying to learn this, you know. So it was nice to see their struggles and (laughs) you know, [I'm not the only one]" (SI3). He expressed his opinion that large professional development groups, where he felt that his learning had been controlled, were a waste of time. In contrast, he described the small group as " . . . more facilitative and kind of guiding our thinking so we all felt valued. You know what I mean? You felt like you were contributing" (SI3). At the end of the study he described the participants as, "good people, good friends" (SI3).

In the beginning, Kathy was very hesitant to share her mathematics thinking. She had a difficult time thinking about operations in any other way than by using a standard algorithm. Even when she tried strategies that the others were using, she would use the standard algorithm to check to see if her answer was right (HJ7). Through encouragement and verbal persuasion, Kathy began to feel more comfortable sharing her ideas. During the second interview she stated as follows:

> I like all our discussions. I like the way you don't make us feel—when we answer—that the answers aren't very bright. You are always able to reinforce whatever we say, so I kind of like the way you handle us so we don't feel stupid. I

> like the way there [are] a lot of different approaches and you point them out. And the way you don't just say, "Okay, that's our one right answer." You ask everyone what their answer is and we give you our opinion and we've all done it different ways so we can see there are lots of different ways to do it. (KaI2)

The small size of the group allowed time for everyone to share and discuss ideas in a way that would not have been possible in a larger class setting. Each person had the time and opportunity to share strategies, ask questions, and express their concerns with the whole group. They had immediate access to the knowledge of the facilitator and the power to contribute to the content and structure of the group study and discussions. These are opportunities that are rare or nonexistent in large group settings. Lexi expressed the feelings of the participants this way:

> I feel the biggest difference is in the small group you have your own needs and concerns addressed more readily. Where in the big classroom or the whole faculty, a lot of the things that happen don't really apply to you. Or, sometimes that's not something you're having an issue with so it doesn't really mean as much. And, in a small group you can focus on the individuals and the things that you really have concerns with. (LI3)

The size of the group and the longevity of the study facilitated a shift in the locus of control. In the beginning of the study I was concerned because the group looked to me for all knowledge and direction. After the first meeting I noted, "After reading the exit cards, I realize that [the participants'] expectation of my role in the group is the same as their expectation of themselves as teachers; they exist in the classroom to give students knowledge" (HJ2). I began to examine carefully how I interacted with the group and contemplated ways in which I could give the group more control. In the second meeting lesson, I chose to begin the lesson and then let the participants' questions guide the direction of instruction. We moved from subtraction strategies to a discussion about developing place value understanding (Kendra's concern). I invited members of the group to share their concerns and ideas about place value instruction. All of the participants expressed concern about their struggling students in this area. Lexi offered an idea for instruction and we decided, as a group, that we would focus on place value during one of our meetings (HJ4).

Lexi's willingness to share opened the door for others to see value in the contributions of each other. Lexi was also the first one to begin asking questions of the group rather than waiting for me to ask the group questions (HJ17). Her story describes how the longevity of the study and small size of the group aided her transformation as individuals within the group became at ease with one another, allowing the locus of control to shift:

> I think it's good because you get to know each other a little better and so working with the same people over and over, you start to feel more comfortable and come out of your insecurities that you keep trying to hide from . . . the group. You're more willing to share and be more open that way. (L13)

Kendra appreciated Lexi's place value idea and in a later meeting expressed the desire to have even more sharing as a group (KeE3). She described changes within the group as the participants overcame their reliance on me and began to teach each other:

> I've liked meeting with the different people and the fact that we've tried the stuff on the board and different people just [pause] it's been really positive. I've never been made to feel stupid or anything and we share our ideas. Like [Scott] will bring in a worksheet or we'll bring in a manipulative, stuff like that, ideas. (KeI2)

As Kendra participated in the group she came to see the other members as colleagues to whom she could turn as resources. She mentioned how she enjoyed meeting with teachers who had different years of experience and were from different schools. She appreciated their commitment to learning. “It seemed like we were all [pause] interested in learning and trying and committed to reading the articles and stuff” (KeI3).

The participants grew from a group of individuals into a dynamically interconnected learning community. As they began to feel safe with one another communication became less inhibited. They came to value one another’s ideas and opinions. They saw each other as professionals who could learn together. Even though it was difficult for them to give up the time in order to meet, they were excited to come to the meetings and felt that they gained from their participation. Kathy summed it up as follows:

> I think all of us gained; I know for a fact. There were so few of us that we could just really observe each other’s comprehension of it. . . . I think everybody grew; I think you helped each one of us. I don’t think there was anybody left behind, even those that have been around for a while and are working on their doctorate [laughs] That says a lot! (KaI3)

The context of the PDSG provided a setting in which I could attend to the general and personal teaching efficacy beliefs toward *Standards*-based mathematics of each participant. Indeed, as the group developed into a collaborative learning community and trusting relationships were established, participants became comfortable talking about their beliefs about their ability to teach *Standards*-based mathematics effectively. Additionally, they were willing to let down the barriers that shielded those beliefs and examine them. The following two sections discuss how attention to teacher efficacy beliefs while nested within the context of the group facilitated a positive change in both general and personal teacher beliefs and as a result, influenced changes in the teaching practice of the participants.

General Efficacy toward Standards-based Mathematics

In this section, I will discuss the results of general teacher efficacy belief change that were revealed in the analysis of data. Evidence revealed changes in general teacher beliefs in a positive direction in each of the participants. Additionally, factors were identified that either hindered or contributed to positive changes in beliefs as well as how those changes influenced changes in teacher practice. A description of the hindrances and contributors to positive changes in efficacy beliefs tell the story.

Hindrances to Positive General Efficacy Belief Change

Three hindrances to general efficacy change were identified: (a) prior experiences, knowledge, and beliefs about a *Standards*-based approach to mathematics, (b) need to control student learning, and (c) concern for individual student needs. The most common of these was related to the participants' prior experience with, lack of knowledge of, or beliefs about *Standards*-based mathematics instruction. All six participants had been taught mathematics with a traditional mathematics approach. They had no experience with seeing or participating in *Standards*-based instruction or learning until college or later. Nonetheless, they had all viewed themselves as fairly competent in their own success as mathematics students. Two participants could see that Standards-based instruction could have positive benefits for students. However, four participants were skeptical that such a change in mathematics instruction was necessary or would be beneficial to their students.

Prior beliefs and knowledge. As Claire described her early mathematics education and experiences, she explained that if she worked very hard she could memorize the steps and then get the correct answer. Getting the answer constituted success for her. Then in her college mathematics methods courses, which were based on an inquiry approach to mathematics, she became frustrated. “It was frustrating because I never knew if I got the right answer because I wanted to know if I was right or wrong. Nothing was ever sure” (CI1). With respect to her own teaching she explained, “I like it more when I’m able to have it more direct instruction and give them the answers to their questions” (CI1). Her notions of what was appropriate practice were mediated by her views of herself as a learner and knower of mathematics (see Laplante, 1997; Smith, 2005).

Control of student learning. A need to control student learning also hindered a positive change in general efficacy beliefs. For some it was unsettling to allow students to be in charge of their own learning. There was a sense that students would not be able to do their part in the classroom. For instance, Lexi could see possible benefits for students from *Standards*-based mathematics instruction but did not trust the students to be able to do the kind of thinking required of them to learn:

> I’m kind of visualizing talking about ways to help kids figure out, or discover, or come up with ways to do algorithms and the different concepts that they have for math, because that’s one thing that I struggle with, is letting them figure it out. I want to tell them how to do it. (LI1)

She expressed frustration with “trying to get kids to come up with their own strategies.” When they did not offer immediate responses, she felt compelled to give them the answers.

Finally, Alvin’s concerns about the effectiveness of *Standards*-based mathematics were based on his apprehensions about its ability to meet the special learning needs of his special education students. When asked how he felt about *Standards*-based mathematics, he responded as follows:

> I think there needs to be some good conjunction. I see some weak spots, especially with the kids I work with. . . . and they understand math but they can't do a simple subtraction problem in a reasonable amount of time. So, with the number sense, they need to be able to compute. (AI1)

Alvin prior concerns were that a *Standards*-based approach was inadequate in helping his students gain computation efficiency and that direct instruction, using mathematics algorithms with practice and drill was essential in helping his students' progress.

Contributors to Positive General Efficacy Belief Change

Several factors contributed to the attainment of positive general efficacy for the participants. The two most important contributors were: (a) obtaining a deeper understanding of mathematical content knowledge (specifically numbers and operations), and (b) seeing the benefits of *Standards*-based instruction for students as participants implemented this type of mathematics instruction in their classrooms. Other factors that contributed to positive change in general efficacy were in line with Bandura's Social Learning Theory (1977), namely: (a) vicarious experiences, (b) positive performance attainments, and (c) verbal persuasion. Each of these contributors to positive changes in general efficacy beliefs is illustrated by stories from the participants:

Content knowledge. Kathy described how a deeper understanding of mathematics concepts changed her general efficacy feelings toward *Standards*-based mathematics. Midway through the study, Kathy was asked about how her feelings toward *Standards*-based mathematics had changed:

> A lot! So much. I had no idea. Especially because I have a third grader [her own child]. I can apply it [to her]. I never thought to look at mathematical problems in any way other than just doing them by rote without any kind of understanding of the mechanisms behind it. Now it's like opening up this new door and I certainly have only just cracked the door. (KaI2)

As Kathy's mathematical knowledge increased and her ability to think about mathematics in different ways deepened, the value of *Standards*-based instruction became clear to her. Even though she is not officially responsible for mathematics instruction in her job-share situation, she found opportunities to apply her new thinking as she worked with her third grade daughter and taught spontaneous mathematics lessons in her classroom. She had very positive attainment experiences as the students she worked with became excited about mathematics and gained in their mathematics comprehension. As a result, the change in her feelings about *Standards*-based instruction was quite dramatic. At the beginning of the study she described her attitude toward *Standards*-based mathematics as "vehemently opposed to it" (KaI2). However, at the end of the study group experience, she responded quite differently:

> I'm sold. And that's really huge for me. It's like I'm on board. And I was not because I didn't know. I think that's all the problem with the parents; they don't see it. I had no idea! To walk into a classroom and be able to say, "What's your strategy? What's your strategy?" All these are good; these are good strategies. I had no idea that [it] was acceptable [for students to use their own strategies for solving problems] from all the years I used to teach before to now. It never was taught that way, so it's new to me and it works in the classroom so well for the kids. (KaI3)

Although Alvin began the study with the confidence that he could teach *Standards*-based mathematics when he understood it, he described how his new knowledge influenced a change in his reticence to implement it. Once he implemented

Standards-based instruction in his classroom he was able to see how it benefited his students.

> It's been good. I've taken time to dissect the numbers and not just have [my students] use the algorithm and I can see where their understanding of numbers has improved as opposed to where it was when we first started. (AI2)

At the conclusion of the study he commented on his change in beliefs or his willingness to implement *Standards*-based mathematics instruction in his classroom:

> My confidence to implement is still the same. I think I can do it. But my willingness has more than changed. I'm willing to try now. . . . I've seen its value; I've seen why it would be beneficial, and I'm more willing to try it now that I have the knowledge to back it up a little bit. (AI3)

Clearly, although Alvin maintained a belief that students need some computation practice, his general efficacy beliefs about the effectiveness of other aspects of *Standards*-based mathematics instruction, such as reasoning and communicating, became more positive as he saw these strategies helping his students.

> I've taught a unit and a half of *Standards*-based mathematics using *Investigations* (TERC, 1998) [curriculum], and I can see where it has definite strengths, especially with my group. If I tie it in with some of the rudimentary practice of just over and over repetitive [having the students do repeated practice], I think it's a good match for my group. It's way better than just having them do the same thing over and over and over again. I think it's a good marriage between the two. I like it, especially the manipulatives that we get to use in this kind of mathematics. I enjoy that. (AI3)

Student benefits. Claire's general efficacy beliefs toward *Standards*-based mathematics instruction changed when she observed the positive effects it had on her students' learning. Initially she said, "I always thought it was a good idea but I wasn't really sure. I [thought] it had some kind of standing" (CI2). Although her teaching practice was tied to her own experience as a student (teachers telling students how to do the math and then getting the rights answers), she started implementing the things she had learned in the group meetings. As she taught mathematics in new ways, she began to question her students about their understanding:

> I asked [my students] the other day, "Do you think multiplication clusters help you to solve multiplication problems?" And yes, most of them said that it did. I think that teaching it has helped me to see that's it's helping the kids. It's given me a more positive view, for sure. (CI2)

Other contributors. Other contributors to positive changes in efficacy beliefs support Bandura's Social Learning Theory (Bandura, 1977). He described four elements that were key to changing efficacy beliefs: (a) positive vicarious experiences, (b) verbal persuasion, (c) positive performance attainments, and (d) physiological responses. In addition to the benefits Claire observed for her students, she attributed her changes in general efficacy beliefs toward *Standards*-based mathematics to a combination of the elements described by Bandura (1986). These elements were vicarious experiences through facilitator modeling, verbal persuasion, and positive performance attainments in her classroom. She said, "But coming to the [study group] and hearing your ideas, and what you think about it, and just doing it in my classroom has been really helpful" (CI2).

Lexi, who could initially see possible benefits to students from using *Standards*-based instruction, had a difficult time believing that her students could come up with their own strategies. Like Claire, several factors contributed to her change in general efficacy, including her own content knowledge, her desire to try, positive performance attainments, and student behavior. Understanding that there was a hierarchy of appropriate strategies that students could use with different levels of understanding about mathematics allowed Lexi to relax her control of student learning. She was more willing to place confidence in her students' ability to succeed at different levels of thinking and gave them more time to work through problems. She explained that as she relaxed her control, the students were "opening up more and willing to share more, taking risks more, and not so afraid that they can't say anything if they do get a wrong" (LI2). In essence, they felt more comfortable even when they made mistakes.

Personal Teaching Efficacy toward Standards-based Mathematics

Results also revealed positive changes in personal teaching efficacy toward *Standards*-based mathematics. Again, factors were identified that both hindered and contributed to positive changes in personal teaching efficacy. Hindrances included: (a) prior knowledge, experiences, and beliefs, and (b) insufficient understanding of *Standards*-based mathematics instruction (pedagogical content knowledge).

Hindrances to Positive Personal Teaching Efficacy Belief Change

At the beginning of the study group the participants' personal teaching efficacy toward *Standards*-based mathematics instruction was heavily influenced by their limited experience with it as well as their immersion in traditional mathematics experiences. Even though all of the participants had had some training with an inquiry approach, their prior personal experiences with traditional mathematics instruction as students inhibited their ability to think about mathematics and mathematics instruction in new ways. They had seen and experienced one "right way" to do things. They lacked adequate mathematics understanding as well as pedagogical content knowledge necessary to successfully implement *Standards*-based mathematics instruction and, as a result, they had often had negative experiences in their attempts to use it in the classroom. For Claire, Lexi, and Kendra, being steeped in traditional mathematics and lacking an understanding of *Standards*-based mathematics instructional methods and strategies resulted in fear of making mistakes during mathematics instruction. Thus, they became tied to the scripted lesson plans found in their *Investigations* (TERC, 1998) teacher manuals. This dependency on the text often hindered their ability to see the underlying mathematics principles and connections in the content they were teaching. The inability to think and talk about mathematics problems in new ways and the lack of pedagogical content knowledge, coupled with prior educational experiences, directly affected participants' confidence in their personal teaching ability.

Prior knowledge and beliefs. Claire's story illustrates how prior experiences and beliefs about mathematics learning affected her personal teaching efficacy toward *Standards*-based mathematics. During her own education she learned that she could be successful at mathematics by working very hard and getting the right answer. Then, when she took her college mathematics courses, which were centered around *Standards*-based instruction, she said, "I didn't know if I was doing it right or if I was being successful so I felt like I was not successful and it made me feel really frustrated" (CI1). This sense of failure with her own personal efforts carried over into her instruction. "I like it more when I'm able to [teach with] more direct instruction and give [my students] answers to their questions" (CI1). She also mentioned that in her attempts to teach the *Investigations* lessons she kept her book right by her, with the parts she intended to teach bolded. She would read it and then try to put it into her own words. She felt dependent on the book and feared to deviate from it. "I would have to really read the book and I would have to go and I couldn't skip anything. I'm like, what if they need this? And I couldn't skip anything" (CI3).

Lack of content knowledge. Kathy's, Scott's, and Lexi's limited conceptual understanding of mathematics affected their ability to think deeply about mathematics, which impacted their personal teaching efficacy. Kathy explained the following:

> I am not one of those mathematicians and so I'm hoping that somehow this study class will help me to understand. I don't understand how [*Standards*-based mathematics] works. And that's what I'm hoping; maybe I could understand the depth into the math of how different procedures work. (KaI1)

In the beginning, Kathy was often hesitant to share her work on problems in the study group because she used a standard algorithm. She admitted that she found it difficult to come up with other ways to solve the problems. Even when she began trying some of the other participants' strategies, she would check her work using a standard algorithm. She not only felt inadequate in the study group, but also unable to teach her students because she didn't understand it herself.

Scott also mentioned his need for ongoing study of how mathematics really works because, he said, " . . . this type of thinking is not easy for me" (SE4). He had a desire to help students become more responsible for their own learning, to have more class discussions, and to deepen student understanding. However, he felt unable to do so because of the difficulty he had in changing his personal mathematical thinking.

Lexi had always liked mathematics because it had always been "concrete" for her. She enjoyed the algorithms and the immediate feedback of a correct answer. When she became acquainted with *Investigations* (TERC, 1998), she could see its usefulness in showing children how numbers worked. However, she did not understand how to think that way. It was while being introduced to *Investigations* (TERC, 1998) that she realized all her mathematics 'skill' was based on memorized procedures. She explained how it was difficult for her to think of simple mathematics problems in new ways:

> I don't think I ever grasped that concept. It was just all formulas and algorithms for me. I do think it's beneficial but it's hard for me. I don't' know if my brain doesn't work that way or if I just never taught it to work that way. It's hard for me to go back and rethink it in different ways, to show different ways. When my kids started bringing home homework that said, "Show this problem, 8 + 3, in a different way," I thought, "What is a different way? There is no different way. There is only one way to do this; just 11." And for me you know, it's forced thinking. (LI1)

Lexi's inability to strategize in different ways made her fearful to allow her students to figure it out for themselves. Even though she wanted them to develop and share their own strategies, her need to tell them how to do it often won out.

Lack of pedagogical content knowledge. Without *Standards*-based pedagogical knowledge, participants doubted their ability to implement the *Investigations* (TERC, 1998) curriculum successfully. To Alvin's mind, his ability to implement *Standards*-based mathematics depended only upon obtaining knowledge of the jargon associated with it. "I felt like I was a duck out of water. Everybody was talking this language that I had no understanding of the vocabulary or what anything was" (AI1). He had confidence that he could teach anything, as long as he could understand how to talk about what he was teaching. On several occasions, Kathy also expressed her frustrations at not having the right words to explain her own thinking or to help her students understand the concepts she taught. For example, in our first interview, she expressed that part of her inadequacy as a teacher of mathematics resulted from not knowing "the jargon" (KaI1). Later, in a spontaneous conversation in the hallway, she mentioned to me that she had just taught a mathematics lesson and it went well. However, she said that it would have gone so much better if she just had the right words to use, similar to the ones I used in the PDSG meeting lessons.

The stories of Scott and Kendra also illustrated the hindering power of having insufficient pedagogical content knowledge. Scott experienced a traditional instruction approach throughout his educational career as a student and teacher, including his doctoral program. He was very good at understanding the concepts of mathematics but had problems with the formula memorization required by his graduate professors. His anxiety in these classes created a compassionate understanding of the struggles students might experience with his traditional instructional practices. He had strong desires for his students to understand mathematics in a safe learning environment but had no pattern of instruction to follow. "I want students [to be able to] feel safe in my room, not threatened. That's what I want, because I always felt threatened every day" (SI1). He often expressed a need to see how to apply *Standards*-based instruction in the classroom and wanted to be shown instructional strategies and how to use group work to help children become skilled.

Kendra loved *Investigations* (TERC, 1998) curriculum from her first introduction to it. She was confident in her own personal problem solving strategies but felt a need to gain more understanding of how to teach it in her classroom. She described her desires to understand how to dialogue, question, improve classroom discussions, and use her instructional time more efficiently in order to make her mathematics instruction really meaningful. "I love math; I just want to do it better." During our study group she focused more on my actions as a facilitator of mathematics instruction than on the content and often took notes that described questions and actions I used while teaching.

Contributors to Positive Personal Efficacy Belief Change

The data revealed several factors that contributed to the growth of mathematical teaching efficacy over the course of this study. These factors included: (a) mathematical knowledge and understanding, (b) pedagogical content knowledge for implementation of *Standards*-based mathematics instruction, (c) positive personal, instructional, and student performance attainments, (d) group support and verbal persuasion, and (e) participants' willingness to learn about and apply new understanding.

Content knowledge. As the participants engaged in study group discussions and lessons their ability to understand and think about mathematics in new ways enabled them all to increase in positive personal teaching efficacy. At first we watched videos of students performing problem-solving strategies to give the participants vicarious experiences with new ways of thinking about mathematics. However, after the second meeting, it was apparent that the participants gained more understanding through participating in the problem solving activities themselves. Because of time limitations we could not do both activities. As a result, after two sessions, we abandoned the videos and focused on participant involvement. As the participants' conceptual understanding of mathematics improved, they became more capable of thinking about problems in new ways and their personal teaching efficacy improved. When questioned about what mathematical understanding he had gained, Scott replied as follows:

> I'm getting a lot better. . . . Like when I do multiplication, a lot of times it will be a cluster automatically. I used to carry and stuff. So it's getting a lot more

> automatic that way. And I've also learned a lot more from the kids, two or three more strategies . . . (SI3)

Claire's new understanding helped her to feel more at ease with allowing her students to share different strategies. She was no longer intimidated when they solved problems in different ways because she felt a greater ability to understand what they were doing.

> I'm able to make these connections. . . . I guess that comes with the strategies, different ways of thinking about it. . . .I think I feel more comfortable with this program now. I feel a lot more comfortable just understanding where they're going with it, you know. . . .I can also understand their [students] thinking better because I can come up with different strategies. (CI3)

During one study group session, Lexi learned about the hierarchy of problem solving strategies. For example, there are multiple ways to think about a subtraction problem and get the right answer, but some are more sophisticated than others. This understanding enabled Lexi to help all levels of learners in her classroom.

> I did not know there [was] a hierarchy. I mean it makes common sense. And to think about it I guess I knew but I didn't know that it was ever really leveled and that this was lower level thinking and that this was higher-level thinking. And that has really helped me. It's helped me challenge my higher kids a little more so that everybody doesn't have to be on the same level. That was a huge epiphany for me. You know, I just hadn't thought about it I guess. (LI2)

As Kathy's understanding of mathematical concepts increased, she was more willing to apply those concepts to children she worked with. Immediately after learning about addition and subtraction strategies, she went home and helped her daughter with her homework. She wrote, "I helped my daughter with her math and [I was able to understand her methods] and was able to help her" (KaE2). Later in the study, she applied her new understanding of multiplication strategies and fractions in her classroom. She described both experiences as positive because as she learned about *Standards*-based mathematics and became better acquainted with the strategies she felt more capable of teaching her students about it. She wrote, "I understood what I was talking about" (KaE7). She described her feelings about her mathematics instruction as "getting better all the time as my understanding develops" (KaE6). By the end of the study Kathy portrayed her teaching efficacy this way:

> I definitely [understand] connected math more comprehensively than before everything we covered. I was able to understand why addition, you know, is the way it is, subtraction, division, multiplication. I think I made the connections I need so I can teach that to my children. (KaI3)

Alvin also attributed his positive change in personal teaching efficacy to new knowledge about *Standards*-based mathematics. He described the change that occurred in this way:

> I wanted to get a better understanding of the math that was being taught in our school. I felt like I was a duck out of water. Everybody was talking this language that I had no understanding of the vocabulary or [what] anything was. So I just wanted to get in the pond. And I did more than get in the pond; I think I can swim pretty [well] now. I'd like to be able to swim faster [chuckles]. (AI3)

Kendra's new understanding about *Standards*-based mathematics gave her more confidence in defending it at parent-teacher conferences:

> I've always supported *Standards*-based math and I've really been positive about it towards the parents. . . . this winter I was even more confident. I'm able to feel more confident about it, like, "Oh, this is why we need it", than I have [previously]. I've always been positive about it. Now I feel like I know more why. (KeI2)

Pedagogical content knowledge. Gaining mathematics pedagogical knowledge was also a key factor in changing teacher efficacy. It became apparent during the course of our study group meetings that the participants were beginning to be able to change their mathematical thinking but still felt a lack in understanding the instructional methods to facilitate their students' understanding in the classroom. After the first three meetings, I began to encourage the participants not only to think about the mathematics we were doing, but to also be aware of the instructional methods that I used during the mathematics lessons. I modeled the mathematics instruction after the inquiry approach that I use in my own classroom. I also set up times with each of the participants either to observe me in my own classroom or to have me come into their classrooms to model a lesson for them. These vicarious experiences helped them to visualize what *Standards*-based mathematics instruction looked like and gave them greater confidence in their own ability to succeed at it.

During the first interview, Alvin commented that he was tired of theory; he wanted to see some practical application. When thinking about the modeling experience in his classroom, Alvin remarked as follows:

> It helped me in showing how far you broke down the division lesson before you started building it back up. I never would have thought to take it down as far as you took it before I started teaching. So that was extremely beneficial. And then you did the "to, with, and by" excellent. You showed it, you did it with them, and then you had them do it. And I think my group especially, enjoys success when they have a good "to, with, and by". If you skip any of those components, they always struggle. . . . We always did the "with and by" . . . but the "to" seems to be important because it kind of gets them going down the right road. And then we break into small groups and do the "with and by". So I've changed that completely since you came in and modeled in my classroom. (AI3)

Kendra's teaching efficacy also improved as she gained increased pedagogical understanding. She wrote about revisiting some *Investigations* (TERC, 1998) activities after a study group lesson in November in which I modeled place value instruction. She commented about that experience, "I was more confident with showing different strategies. I'm still getting better at place value; I even did better in terminology and walking through the problems with correct place value" (KeE5). Kendra described her change in efficacy at the end of the study:

> That one day that you came into my class and showed me just a couple of little things—well maybe they were big—it just seemed like, wow, this is so easy. If I just thought about the lesson a little bit more every night I'd be so much better. And just going through strategies like seriously, I didn't know the division. So, physically going through the stuff and watching the tapes, that helped me too. (KeI3)

Scott repeatedly stressed his need to see an *Investigations* (TERC, 1998) lesson taught in the classroom. He had the unique opportunity of observing both his student teacher and me model *Standards*-based mathematics instruction in his classroom. At the mid-point of the study group experience, he was asked to describe his feelings toward his ability to implement *Investigations* (TERC, 1998) lessons. He responded, "It's gotten better. . . . My student teacher has modeled a unit on 3-D geometry and that helped me, too because I have to see it! I find that I'm either hands-on or visual" (SI2). In response to the same question at the end of the study:

> Again, in my head I know more what's expected of the kids, and what I feel I'm doing better at is . . . I want to do more what you were doing with our class. Like having them share strategies—that's something I want to do; that's my next focus. (SI3)

Later in the interview he mentioned that he was doing more modeling, monitoring, and using story problems similar to what he had seen me do in his classroom.

After a classroom modeling experience, Claire commented as follows:

> I can really look at how can I make it so that it makes more sense to the kids. . . . Sometimes when you were teaching, I was just thinking, 'You know, they're pretty smart kids.' It sounds so silly but that's what I was thinking, you know. Like they do get stuff, and you were really excited about it and they were getting more into it . . . (SI3)

It is important to note that the participants were still using traditional language to talk about their new learning at times. This was not unexpected. The important notion to be considered is that the participants were moving toward a deeper knowledge of mathematics and more positive general and personal efficacy beliefs about *Standards*-based mathematics.

Positive performance attainment. A third key factor in improving personal teaching efficacy proved to be positive performance attainments for the participants and their students. For example, as the participants experienced success at new types of problem solving they became excited to try it out in their own classrooms. Then their new knowledge, both content and pedagogical, helped them have positive performances in their classrooms and led to positive performance attainments for their students. It is also interesting to note that the participants began to gain more new knowledge as they learned from the thinking of their students. Some experiences from Claire's story provide a good illustration. Midway through the study she described her change in personal teaching efficacy:

> Just doing; like coming up with the strategies, I feel more confident in coming up with strategies because I was able to work on it and talk about with our partner and then you know, share them. So I feel more confident that I know what I'm doing. . . . I don't know if I really realized until looking back that I have grown a lot in my ability to teach math and also I just feel more confident in doing it. (CI2)

After a division lesson, she also noted that her experience was positive, "I not only better understand what my students are doing but I can model this strategy" (CE4). Later, during the final interview she talked about her personal efficacy again:

> Every time that I left [study group] I know that I thought of something in a different way than I'd thought of it before, but it wasn't something that I had

> never known. It was just something that I thought of in a different way. So, I guess it's helped me to become a better teacher because I just feel more confident that I know how to do . . . multiplication, division, those kind[s] of things. . . . I've changed . . . and that's not only helped my kids but it's helped me to see that that's what division really is. I don't think I understood that before. Division is just taking groups of a number out of a whole number. (CI3)

Even though Claire was still a little bit unsure of her ability to get the students to share, she felt that next year she will be much more effective.

During an extemporaneous conversation in the hall, Kathy also shared an experience in teaching multiplication in her classroom the day following study group. She commented on how well the lesson had gone and that she was able to guide the students in discovering different strategies. They were excited about understanding, discovering, and sharing new thinking. She commented that it was almost as if they were a sounding board for her helping her to cement it in her mind. Because of positive attainment experiences like this she said, "I'm planning on and hoping to teach it on a regular basis" (KaI3).

Other factors. Other factors that contributed to improved personal teaching efficacy included group support, verbal persuasion, and the participants' desire to learn and willingness to apply their new understanding. Collaborating together allowed the participants to associate with others who had the same questions and concerns about their mathematics instruction. Knowing that others were struggling helped them to feel less stressed about their own level of mathematics teaching ability. For example, in two different interviews Claire mentioned that the discussions helped her to see that she was doing some things right. The group conversations helped her to feel more confident in her teaching ability. She stated, "If I didn't go to the class [study group] I would still wonder if I'm doing anything right" (CI3). Similarly, Scott (the doctoral student) talked about feeling better about himself as a teacher when he was able to see that others had the same kind of questions and concerns about mathematics as he did. "I thought it was just nice to have a support group. We're all trying to learn this, you know. So it was nice to see their struggles and [to know that] I'm not the only one" (SI3).

Kathy gained confidence from being in the group in a different way. Through working on the problem solving during lessons, she discovered that everyone can have a different way to solve a problem and that was acceptable. She said, "I loved the way we looked at each others' [problem solving] and saw how we were all different from each other and it's all okay because we came to the same answer in the end (KaI3)." She also felt more confident from the verbal persuasion of the participants and facilitator. As her fragile understanding of operations developed, the group applauded her efforts and I encouraged her growing thinking. She expressed it this way, " . . . from the very beginning you were praise, praise, praise. 'You're fabulous, you're fabulous!' I walked away going, 'I'm fabulous!' knowing I really wasn't but you made me feel like it" (KaI3).

Finally, each person in the group came with a desire to improve their *Standards*-based mathematics instruction. They were willing to learn new things and had a desire to put new ideas into practice. Even Kathy, who wasn't responsible for mathematics instruction in her classroom, was anxious to try out what she learned after each session with her students. As each participant applied new content and pedagogical knowledge, they had both positive and negative performance attainment experiences. However, both types of experience helped their desire to improve mathematics instruction increase. The positive experiences gave them greater confidence in their teaching ability; the negative experiences spurred them to seek out greater content and pedagogical knowledge. Participants also came to group meetings with more specific questions. They requested that lessons be modeled. They expressed an interest in having the group be ongoing.

Although some group members felt that they still had more to learn to be fully confident in implementing *Standards*-based mathematics in their classroom, each participant did change in a positive direction in both general efficacy and personal teaching efficacy.

CHAPTER 5

DISCUSSION

On the subject of change in teacher practice, Guskey and Richardson argued two opposing perspectives. On one hand, Guskey (1988) maintained that long-term change in practice can result only as teachers experience reform-based instruction in their classrooms. He suggested that as teachers put reform measures into practice and they notice positive changes in student performance, long-term changes in practice will occur. In contrast, Richardson (1996) contended that teachers must change their beliefs in order for changes in their practice to occur and to become long term. While both arguments are valid, this study suggested another perspective. It was clear that as teachers' developed a deeper content and pedagogical content knowledge about mathematics their beliefs in the effectiveness of a *Standards*-based approach to instruction became more positive. In addition, their beliefs about their ability to implement a *Standard*-based approach to teaching mathematics in their own classrooms also improved and they began to have a greater desire to implement such practices. Thus, a change in practice and a change in beliefs occurred almost simultaneously.

The teachers in this study came to think differently about mathematics instruction while they implemented new instructional methodologies. Within the framework of the PDSG, the participating teachers felt that they were able to try out new ideas and practices as they were learning them. They were able to see how changes in practice led to student improvement while they were simultaneously involved in dialogue that led to a deeper understanding of mathematics content and pedagogy, and a change in their beliefs about teaching and learning mathematics. In addition, as they worked with their students, the teachers' knowledge of content was solidified (Kennedy, 1998). Thus, group interaction with peers who were facing similar challenges and successes helped each individual to recognize and reflect on their beliefs as they engaged in practice based on those beliefs.

In this chapter, I will discuss how the nature of a PDSG as an alternative form of professional development enabled participating teachers to attend to their beliefs about teaching and learning mathematics and a willingness and desire to re-examine themselves as learners. More specifically, I will describe how attending to teachers' general and personal efficacy beliefs about mathematics and its instruction, as well as their content and pedagogical content knowledge, while nested within the context of the group's development was essential to the evolution of these teachers' mathematics efficacy beliefs. The transformation of these beliefs then led to a willingness and desire on the part of the participants to put mathematics reform into practice and to do so effectively.

Professional Development Context

Scott compared his experiences with traditional professional development and the PDSG. He described a traditional experience as a large group with one big shot or point made by a presenter who was distilling information. Even when the group was divided up into smaller sections he said, "I felt like we were being controlled. There was an agenda that you knew you were supposed to get and I didn't like that" (SI3). He portrayed large groups as ineffective and a waste of money. In contrast, he describes the PDSG as allowing the participants to become good friends:

> It was good to meet with them so you weren't just wasting your time. Because I've been in some that, you know, I didn't want to be there and this [PDSG] was

> enjoyable. . . . I've been in some where it's, "I'm the boss, you're the peon." You know what I mean? [The PDSG] was more facilitative and kind of guiding our thinking so we all felt valued. You know what I mean; you felt like you were contributing. (SI3)

Scott's responses illustrated how the development of the group allowed the participants to become active contributors in their own professional development. They were able to develop friendships and relationships in the context of the group that enabled them to feel safe revealing and analyzing their own thinking and beliefs about mathematics and mathematics pedagogy. They were given a voice in determining the scope of the content to be covered and the direction that the group pursued during discussions. The PDSG provided a context in which the participants had a vested ownership in their thinking and learning as well as a safe environment to question and explore *Standards*-based mathematics. Within this context the participants were able to set aside mental barriers that shielded their beliefs so that these beliefs could be examined and altered. Skepticism about the value and feasibility of *Standards*-based mathematics was replaced by assurance that it could be taught effectively and that it could improve student understanding about mathematics. Doubts about personal ability to implement mathematics reform were exchanged for confidence. These findings confirm several elements of effective professional development as outlined by Darling-Hammond and Ball (1998), Huberman (1995), Loucks-Horsley, Stiles, and Hewson (1996), and the NRC (1999).

General Mathematics Efficacy Beliefs

Keys to changing the general efficacy of the participants were (a) gaining deeper content knowledge of mathematics, (b) seeing it successfully modeled, and (c) experiencing successful and effective implementation of that new knowledge in their classrooms. The participants engaged in learning and understand mathematics concepts more deeply through lessons using a *Standards*-based instructional approach. As a result, they realized that *Standards*-based mathematics instruction could potentially positively impact their students' mathematical knowledge in a similar way. In other words, they came to believe that *Standards*-based mathematics was an effective way to teach mathematics. As the participants saw *Standards*-based mathematics successfully modeled during PDSG lessons and in their classrooms, they developed beliefs that it was possible to teach in this way. Both of these experiences encouraged the participants to implement *Standards*-based mathematics instruction in their own classrooms (an indication of the influence of positive general efficacy beliefs on positive personal efficacy beliefs). Through these classroom experiences, the participants saw their students being successful using this type of instruction. As a consequence, their beliefs in *Standards*-based mathematics as an effective way to teach mathematics were strengthened. The PDSG enabled the participants to experience each of these three elements.

Kathy's transformation in general efficacy beliefs sheds light on the changes possible toward general teaching efficacy. When she talked about *Standards*-based mathematics she said, "I was vehemently opposed to it. When I took it and I had the summer class . . . I did not understand what I was teaching at all. I did not know why [we were] doing this" (KaI2). Although traditional teacher development experiences offered Kathy information about the principles of the mathematics reform and lesson ideas, there was nothing offered that prompted her to examine its benefits in terms of student learning. In fact, as a result of the traditional teacher development experience she became more opposed to reform; it was a lot of hard work to change with no obvious reasons or benefits for doing so. Her own beliefs and experience involving traditional mathematics and her lack of fluent mathematical knowledge had not facilitated successful experiences in implementing *Standards*-based mathematics in her own classroom. Instead, the curriculum was a burdensome necessity.

However, during Kathy's participation in the PDSG she began to examine her own mathematical understanding and realized that she relied heavily on standard algorithms. On more than one occasion she commented on her shallow understanding of place value (KaE3 & E4). She recognized the efficiency that other members of the group were acquiring as they practiced decomposing and recomposing numbers in developing new ways of solving mathematical problems. As a result, she began to try new methods and became excited in her new and deeper understanding of simple operations, so much so that even though mathematics instruction was not her responsibility in her job share situation, she could not wait to put her new mathematical knowledge into practice in her own classroom.

As Kathy developed new ways of understanding mathematics, she became empowered to alter her beliefs about the value of *Standards*-based mathematics instruction for her students. Her experience in watching me model effective *Standards*-based instruction gave her confidence that this type of mathematics instruction was possible and would benefit her students in the same ways it had benefited her. In concert with Richardson's (1992) research findings, at the end of the study Kathy's general efficacy beliefs had changed dramatically. In describing her current feelings about *Standards*-based mathematics she stated, “I’m sold! And that’s huge for me.”

Although Kathy’s experience proved to be the strongest with respect to this type of change in general efficacy beliefs, her experience is representative of others in the group who had similar experiences in their beliefs about *Standards*-based mathematics. The stories of Claire and Scott are used as further illustrations:

After Claire’s experiences with *Standards*-based methodology courses in college, she felt that there was no real point to this type of instruction. Her questions were left unanswered and she felt that she had no measure of her success. As a result, she reported that she liked direct instruction better. Although she was following *Investigations* (TERC, 1998) curriculum in her classroom as directed by school administration, she explained that she did not use a discovery approach but tried to “make it more concrete [used direct instruction]” (CI1). Two things happened within the context of the PDSG that enabled a transformation of Claire’s general efficacy beliefs. First, she developed a trust in me as a professional. Midway through the PDSG she explained that her feelings toward *Standards*-based mathematics instruction as more positive as a result of, “hearing your ideas and what you think about it” (CI2). Second, she explained that she was able to think more deeply about mathematics. She described the effect content and pedagogical content knowledge gained from lesson modeling in the PDSG and in her classroom had had on her general efficacy beliefs about *Standards*-based mathematics. “I’m able to make connections . . . and [as a result] I think I feel more comfortable with this program” (CI3). When asked about her feelings toward *Standards*-based mathematics, she expressed some doubt because, "Any program [has] strengths and weaknesses. However, she now felt that *Standards*-based mathematics had many strengths. She explained, "I feel good about it [*Standards*-based mathematics]. . . . I think it's a good idea" (CI3).

Scott's style of teaching was also primarily direct instruction. As a result of his great concern about high-stakes testing, he had implemented a system of direct instruction followed by review that would prepare his students for end-of-year testing. During the PDSG he was able to observe me model effective *Standards*-based mathematics instruction during group lessons and in his classroom. He also observed his student teacher modeling this type of instruction in his classroom and during a lesson in a PDSG meeting on fractions, Scott was challenged. He described the experience as "difficult" but "fun" (SI3). These experiences helped him to see what the students were going through in his own classroom. As a result, he came to the determination that learning and understanding the concepts was more important than learning procedures. When asked about his feeling toward *Standards*-based mathematics in the final interview, he explained that he had realized that student success came when students learned and understood mathematics concepts and then developed the "formulas" [standard algorithms] (SI3).

Personal Mathematics Teaching Efficacy Beliefs

Once participants held positive general efficacy beliefs about *Standards*-based mathematics the door was opened for them to begin to develop their own personal mathematics teaching efficacy beliefs. Factors that enabled positive change in personal efficacy were (a) gaining deeper content and pedagogical content knowledge, (b) developing positive general efficacy beliefs about *Standards*-based mathematics instruction, and (c) experiencing successful implementation of *Standards*-based mathematics instruction in their classroom.

Kendra was an example of one who began the study with positive general efficacy beliefs about *Standards*-based mathematics. She simply wanted to learn how to be better at instruction so that she could feel more confident. The initial general efficacy beliefs of others in the group ranged from total opposition or a skeptical outlook to a hesitant concession that there might be some value to *Standards*-based mathematics. However, as participants' general efficacy beliefs began to change, they developed a desire to become better teachers of this type of mathematics instruction. They were eager to learn new content and pedagogical practices and to implement them. The structure of the PDSG supported their learning and their efforts to change practice in a way that allowed them to develop more positive personal efficacy beliefs about *Standards*-based mathematics instruction.

Kendra and Lexi provided examples of positive personal efficacy change as a result of gaining improved content and pedagogical content knowledge. Kendra was motivated to put new place value strategies into practice after gaining new insights about place value in her work within the group. In addition, the team-teaching experience she and I shared in her class and her observations of my lesson modeling in PDSG helped her gain pedagogical content knowledge. After the teamed classroom experience, she expressed, "Wow, this is so easy!" (KeI3). She also wrote about how the modeling of questioning and student sharing strategies during PDSG helped. When asked about experiences in her classroom she described a division lesson in which she had used student strategy sharing. She reported, “It actually worked and the kids listened to others sharing!” (KeE2). After our fifth meeting she wrote, “I revisited a few games and problems. . . . I was more confident with showing different strategies” (KeE5). When asked about her feelings about her ability to implement *Standards*-based instruction, she replied, “I think I’m more equipped now to [teach] it . . . . I have more confidence now” (KeI3).

Lexi, too, had been struggling to teach an equivalent fraction unit and was very excited when she learned patterns for equivalent fractions. She applied her new understanding [content knowledge] in her classroom and reported much more successful lessons. During PDSG I specifically modeled questioning strategies in the lessons. After I modeled in her classroom, she said, “I loved that. I learned some strategies . . . that I could implement . . . how you talked them through their sharing. I learned a lot [through that experience]. But I also learned that some of the things I [am] doing [are] okay” (LI3).

Claire’s experience is a good illustration of how changes in general efficacy beliefs lead to changes in personal efficacy beliefs. Her earlier encounters with *Standards*-based mathematics instruction left her feeling frustrated. The first of these experiences came in college. She described her courses as frustrating because she usually felt like the instructors and the participants talked and talked but never came to any conclusion; she never knew if she got the “right answer” (CI1). Mathematics success for Claire had always meant working really hard and getting the correct answer. She felt her college professors were so entrenched in promoting a discovery approach to instruction that they never got to the point of learning. Inevitably, when she ventured a question they responded with a question in return. She found this response to her questioning frustrating. Then, upon beginning her first year teaching with *Investigations* (TERC, 1998) curriculum she described her tendency toward direct instruction:

> I find myself trying to show them how to do things. . . . I like it more when I'm able to have it more direct instruction and give them answers to their questions. My teachers were more discovery like way into discovery in their own methods than I am in teaching. I'm not as—well because I'm just learning how to do it—I'm not, "Discover your own ways". I'm not like as much into it as, you know. [pause] I don't know if I'm really doing it right. (I'm probably not.) So I follow the plan but I try to make it more concrete. (CI1)

Although Claire felt that she was faithfully trying to implement the *Investigations* (TERC, 1998) curriculum, she was hindered by her own frustrating experiences of being uncertain of her mathematicsknowledge coupled with the fact that she felt her own teachers in teacher education never directly answered her questions about mathematics and mathematics teaching. *Standards*-based mathematics had not been valuable for her and it was difficult for her to feel confident in teaching her students in the prescribed method. She wanted to come to the PDSG to glean effective teaching ideas so she could become a better teacher so "the kids can learn". She talked about her hopes:

> I really hope that my kids will learn and they'll get it [more easily] because I'll be able to explain it [clearly] and just know how it works so that they can learn. I want to have them share more, feel more confident to share. (CI1)

The supportive relationships that developed within the context of the group allowed Claire to examine her own mathematical thinking in a relatively risk free environment. After just two group meetings she commented that she was learning new strategies and that mathematics instruction in her classroom was getting better (CE1 & CE2). At this early stage in the PDSG experience she still had questions about how much she could “tell” her students and how she could get them motivated to participate in groups. However, she felt very positive about participating with the group. It was comforting and confirming to see more experienced teachers having some of the same concerns (CE3). By December, the seeds of a positive change in personal teaching efficacy beliefs were beginning to sprout:

> I think [the group] has been really helpful. I’ve really liked it. It’s been really helpful to come together and just to talk about math and get ideas. I’ve been able to use a couple of the things this week in my class that’s really helped my kids. . . . And just being able to share strategies has helped me to be able to teach my kids how to use strategies and I feel confident. . . . It’s good to see that there are common things that are hard for people so I don’t feel alone. (CI2)

She also began to express an interest in seeing what *Standards*-based mathematics instruction might look like in the classroom:

> Sometimes they’re sharing strategies and I don’t know if it’s a good [thing]. I’m thinking, “I don’t know if that’s really going to work” you know, and so we’ll do it. But sometimes I’m afraid they have good ideas but I don’t let them share those ideas because I don’t know what they are talking about. (CI2)

In the group meeting we began working through multiplication and division concepts. Claire was learning how to think about the meaning of the operations and how the numbers could be decomposed and recomposed. She had an excellent grasp of mathematical procedures and the context of the group allowed her the time and support to develop her mathematical understanding in explicating the reasoning behind these procedures. She was able to come up with “the right answers” in different ways and help other members of the group by explaining her thinking. Her skepticism about this type of mathematics instruction began to dissipate as successful experiences in the group helped her to see how her own personal learning could be facilitated. Then, she applied her newly developed understanding and knowledge in her next mathematics lesson and reported back to the group that the experience had been very positive, "I not only better understand what my students are doing but I can model this strategy!" (CE4).

In the final interview Claire talked about how the group had developed into a comfortable environment where the participants could share ideas and help one another. As she learned new ways to look at mathematics and was able to analyze those ideas within the context of the group experience, Claire became more confident as a teacher. She had always felt like she was good at mathematics, but in the group she realized that she did not understand different ways to think about numbers and operations. At the end of the study when asked about what she had gained from participating in the PDSG she replied as follows:

> Definitely, I've gained a lot of knowledge [content knowledge], confidence in myself doing math. I always felt like I was pretty good at math before but I feel like I have a new perspective of how to do simple things in different ways and you know, I know how to do the math. (CI3)

Newly acquired content knowledge affected a change toward more positive personal teaching efficacy. She explained that being involved in the PDSG and learning new ways to look at mathematics, "helped me to become a better teacher because I just feel more confident . . . that I know how to do those kind[s] of things [solve mathematics problems] in different ways [using a variety of strategies]" (CI3).

Claire's personal and general mathematics teaching efficacy were intertwined with one another. As one changed it influenced changes in the other:

> I'm able to make these connections, different ways of thinking about it. And I think I feel more comfortable with this program now [has more confidence in its effectiveness or general efficacy]. I feel a lot more comfortable just understanding where they're going with it. . . . And I also can understand their [her students'] thinking better because I can come up with different strategies [her ability to teach or personal teaching efficacy]. (CI3)

As she grew in mathematical content and pedagogical content knowledge through PDSG, it became clear that she placed more confidence in the potential of *Standards*-based mathematics instruction to influence children in similar ways (general efficacy). She also acquired greater confidence in her ability to teach using this type of instruction (personal efficacy). Then, as she implemented newly acquired content and pedagogical knowledge with positive results, her general and personal efficacy increased.

As each participant experienced positive changes in beliefs about *Standards*-based mathematics his/her willingness to implement changes in practice became automatic rather than forced. Changes in beliefs and practice were supported and encouraged in the group meetings. Participants shared their successes and failures and relied on one another for ideas to improve practice. The group meetings provided a safe context in which the participants could examine themselves as learners and teachers.

Conclusions

The results of this study support the strong potential that a PDSG as an alternative form of professional development has to facilitate changes in teacher thinking and teacher practice (Jenlink & Kinnucan-Welsch, 2001). The framework and structure of this type of professional development allowed attention to be devoted to the general and personal efficacy beliefs of the participants and, in doing so, revealed the role of efficacy in effecting teacher change—understanding what to teach and how to teach it gave teachers the confidence to do it (Darling-Hammond & Ball, 1998). The teachers in the group had each volunteered to participate, wanting to improve their practice in teaching reform based mathematics curriculum. Therefore, they took ownership for their personal professional development. The framework of the PDSG provided a context that allowed participants to have a vested interest in one another and the development of the group by giving them a say in the content and in the direction of the discussions.

Additionally, like Loucks-Horsley, Stiles and Hewson (1996) found, teacher learning best occurs over time. Thus, the six-month duration of the PDSG provided the time needed for relationships to develop and a safe context to be created. Within this context teachers had the opportunity to investigate the potential benefits that mathematics reform offers to them and their students. The small group context also provided time to think deeply about mathematics concepts, examine their own thinking about mathematics, and become aware of their beliefs and personal mathematical knowledge. They were able to redefine themselves as learners and thus gain a new sympathetic perspective of their students as learners. As Huberman (1995) and Loucks-Horsley and Matsumoto (1999) suggested, teacher development experiences can promote revision of teacher thinking and beliefs.

Too, the opportunity to gain and put into practice new content and pedagogical knowledge while simultaneously unpacking their general and personal teaching efficacy beliefs toward *Standards*-based mathematics allowed beliefs to change in a positive direction (Ross, 1994). Once these positive efficacy beliefs were espoused, participants were motivated to continue to make changes in their practice so that their students could have learning experiences similar to their own. This result supports the notion that teachers' instructional practices are mediated by their beliefs about themselves as learners and knowers (Laplante, 1997; Smith, 1995). The process became cyclical; as teachers had successful experiences with students in their classroom, general and personal mathematics teaching efficacy improved. In turn, increased positive teacher efficacy led to a renewed motivation to change practice.

Implications for Practice

Although the results of this study cannot be generalized and do not account for the context of every study group type of professional development, the findings do provide encouragement for schools and districts that are looking for alternative forms of professional development. In particular, those educational institutions that are planning or are in the process of implementing reform in teacher beliefs, practice, or curriculum might consider the PDSG form of professional development as a viable way to motivate teacher change with less resistance on the part of the teachers. There is evidence to support the idea that once highly motivated teachers are on board with change, their enthusiasm can be infectious in motivating others to join them (Burbank & Kauchak, 2003).

The present research revealed that the effectiveness of a PDSG is highly dependent upon four criteria. First, content of the PDSG lessons and discussions must meet the current needs and concerns of the participants. This notion supports the findings of Garet and his associates (2001) who identified meaningful content connected to practice as one of the essential elements in effective professional development. Second, the context of a PDSG needs to include adequate group collaboration and instruction time, necessary long-term duration, and a small number of participants in order to support relationships and the development of a risk-free environment. Third, the participants of a PDSG must include a facilitator who has sufficient content and pedagogical knowledge to support and encourage participants' learning. An institution desiring to organize this type of professional development would need to take these components into careful consideration. Finally, attention needs to be given to the unpacking of general and personal efficacy beliefs while participants are gaining and putting into practice new knowledge.

Future Research

The author recommends three areas for future research. First, although the results suggested evidence of teacher change in both beliefs and practice, an interesting extension of the study would be to follow the participants for an extended period of time to see if the initial changes became permanent and became a heuristic for continuous change and development. Second, one might investigate the development and effects on change of such a group if it were to remain in tact over a longer period of time. How would relationships change? Would teacher efficacy and practice continue to improve? Would the effects of the group translate across professional contexts or impact personal lives of the participants? Finally, similar studies might be applied to other content or pedagogical areas. For instance, how might the PDAG be applied to classroom management or assessment practices?

REFERENCES

American Association for the Advancement of Science. (1984). *A report on the crisis in mathematics and science education: What can be done now?* New York: J. C. Crimmins.

American Educational Research Association. (2005). Teaching teachers: Professional development to improve student achievement. *Research Points 3*(1), 1-4.

Ball, D. (1996). Teacher learning and the mathematics reforms: What we think we know and what we need to learn. *Phi Delta Kappan, 77*(7), 500-508.

Bandura, A. (1977). *Social learning theory.* Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

Barlow, A. T., & Reddish, J. M. (2006). Mathematical myths: Teahcer candidates' beliefs and the implications for teacher educators. *The Teacher Educator, 41*(3), 145-157.

Battista, M. T. (1994). Teacher beliefs and the reform movement in mathematics education. *Phi Delta Kappan, 75*(2), 462-70.

Bay-Williams, J. M., & Meyer, M. R. (2003). Help! Parents and standards-based mathematics. *Principal Leadership (High School Ed.) 3*(7), 54-60.

Brosnan, P. A., Edwards, T., & Erickson, D. (1996). An exploration of change in teachers' beliefs and practices during implementation of mathematics principles and standards. *Focus on Learning Problems in Mathematics, 18*(4), 35-53.

Bullough, R. V., Jr., & Baughman, K. (1997). *"First year teacher" eight years later: An Inquiry into teacher development.* New York: Teachers College Press.

Burbank, M. D., & Kauchak, D. (2003). An alternative model for professional development: Investigations into effective collaboration. *Teaching and Teacher Education, 19*, 499-514.

Carpenter, T. P., Fennema, E., Franke, M., Levi, L., & Empson, S. (1999). *Children's mathematics: Cognitively guided instruction*. Portsmouth, NH: Heinemann.

Carpenter, T. P., Fennema, E., Peterson, P., & Carey, D. (1988). Teachers' pedagogical content knowledge of students' problem-solving in elementary arithmetic. *Journal for Research in Mathematics Education, 19,* 385-401.

Chokshi, S., & Fernandez, C. (May, 2005). Reaping the systemic benefits of lesson study: Insights from the U. S. *Phi Delta Kappan*, 674-80.

Cobb, P. (1994). *Theories of mathematical learning and constructivism: A personal view.* Paper presented at the Symposium on Trends and Perspectives in Mathematics Education, Institute for Mathematics, University of Klagenfurt, Austria.

Cobb, Wood, & Yackel. (1990). Classrooms as learning environments for teachers and researchers. In R. Davis, C. Maher, & N. Noddings (Eds.), Constructivist views on the teaching and learning of mathematics. *Journal for Research in Mathematics, Education,* Monograph no. 4*,* pp. 125-146. Reston, VA: National Council for Teachers of Mathematics.

Cohen, S., & Hickman, P. (1998). Supporting district implementation: What has CESAME learned. Adapted from SIP: Effective Models for Curriculum Implementation. Presented at the 1998 NARST Annual Meeting. Retrieved July 3, 2004 from http://www.lab.brown.edu/investigations/ spotlight/archive/ supdistimp.html

Cooney, T. J., & Shealy, B. E. (1997). On understanding the structure of teachers' beliefs and their relationship to change. In E. Fennema, & B. Nelson (Eds.), *Mathematics teachers in transition* (pp. 87-110). Mahwah, New Jersey: Lawrence Erlbaum.

Darling-Hammond, L., & Ball, D. L. (1998). Teaching for high principles and standards: What Policymakers need to know and be able to do (CPRE Joint Report Series, JRE-04. Philadelphia: Consortium for Policy Research in Education and the National Commission on Teaching & America's Future.

Day, C. (1999). *Developing teachers: The challenges of lifelong learning.* New York: Routledge Falmer, Taylor & Francis.

De Mesquita, P. B., & Drake, J. C. (1994). Educational reform and self-efficacy beliefs of teachers implementing nongraded primary school programs. *Teaching and Teacher Education, 10*(3), 291-302.

Dickinson, V. L., Burns, J., Hagen, E. R., & Locker, K. M. (1997). Becoming better primary science teachers: A description of our journey. *Journal of Science Teacher Education, 8*(4), 295-311.

Edwards, T. G., (2003). Current reform efforts in mathematics education. *ERIC/CSMEE Digest.* Retrieved July 7, 2004, from *http://web5.5.silverplatter.com/webspirs/* showFullRecordContent.ws

Enochs, L. G., Smith, P. L., Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics, 100*(4), 194-202.

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*(4), 403-434.

Fernandez, C. (2002). Learning from Japanese approaches to professional development: A case study. *Journal of Teacher Education, 53*(5), 393-405.

Foulger, T. (2005). Innovating professional development standards: A shift to utilize communities of practice. *Essays in Education, 14*, 1-14.

Franke, M. L., Fennema, E., & Carpenter, T. (1997). Teachers creating change: Examining evolving beliefs and classroom practice. In E. Fennema, & B. Nelson (Eds.), *Mathematics teachers in transition* (pp. 87-110). Mahwah, New Jersey: Lawrence Erlbaum.

Frykholm, J. (2004). Teachers' tolerance for discomfort: Implications for curricular reform in mathematics. *Journal of Curriculum and Supervision 19*(2), 125-49. Retrieved October 9, 2004, from http://vnweb.hwwilsonweb.com.erl lib.byu.edu/hww/results/results_single.jhtml?nn=15

Fullan, M. G. (1991). *The new meaning of educational change.* (2nd ed.). New York: Teachers College Press.

Fullan, M. G. (1993). *Change forces: Probing the depths of educational reform.* Levittown, PA: Falmer.

Fullan, M. G., & Hargreaves, A. (1992). *Teacher development and educational change.* Bristol, PA: Falmer.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What Makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915-945.

Glaser, B., & Strauss, A. (1967). *Discovery of grounded theory.* Chicago: Aldine.

Glazer, E. M. & Hannafin, M. J. (2006). The collaborative apprenticeship model: Situated professional development within school settings. *Teaching and Teacher* Education 22, 179-193.

Guskey, T. R. (1988). Teacher efficacy, self-concept, and attitudes toward the implementation of instructional innovation. *Teaching and Teacher Education, 4*(1), 63-69.

Guskey, T. R. (2000). *Evaluating professional development.* Thousand Oaks, CA: Corwin Press.

Haney, J. J., & Lumpe, A. T. (1995). A teacher professional development framework guided by reform policies, teachers' needs, and research. *Journal of Science Teacher Education, 6*(4), 187-196.

Heibert, J. (1999). Relationships between research and the NCTM Principles and Standards. *Journal for Research in Mathematics Education, 30*(1), 3-19.

Heibert, J., & Carpenter, T. P. (1992). Learning with understanding. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning*. New York: Macmillan.

Hollingsworth, S. (1989). Prior beliefs and cognitive change in learning to teach. *American Educational Research Journal, 26*(2), 160-189.

Huberman, M. (1995). Networks that alter teaching: Conceptualizations, exchanges and experiments. *Teachers and Teaching: Theory and Practice, 1*(2), 193-211.

Huinker, D., & Madison, S. K. (1997). Preparing efficacious elementary teachers in science and mathematics: The influence of methods courses. *Journal of Science Teacher Education, 8*(2), 107-126.

Jenlink, P. M., & Kinnucan-Welsch, K. (2001). Case stories of facilitating professional development. *Teaching and Teacher Education 17,* 705-24.

Johnson, B., & Christensen, L. (2000). *Educational research: Quantitative and qualitative approaches.* Boston: Allyn and Bacon.

Kagan, D. (1992). Professional growth among preservice and beginning teachers. *Review of Educational Research, 62*(2), 129-69.

Kennedy, M. M. (1998, April). *The relevance of content in in-service teacher education.* Paper presented at the annual meeting of the American Educational Reasearch Association, San Diego, CA.

Korthagen, F., & Kessels, J. (1999). Linking theory and practice: Changing the pedagogy of teacher education. *Educational Researcher*, 4-17.

Laplante, B. (1997). Teachers' beliefs and instructional strategies in science: Pushing analysis further. *Journal of Science Education, 81*, 277-294.

Lappan, G. (2004). *Connected Mathematics Program.* Englewood, NJ: Prentice Hall.

Lewis, A. C. (2006). Math Achievement. *The Education Digest, 71*(7). 69-71.

Lortie, D. (1975). *Schoolteacher: A sociological study.* Chicago: University of Chicago Press.

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

Loucks-Horsley, S., & Matsumoto, C. (1999). Research on the professional developmment for teachers of mathematics and science: The state of the scene. *School Science and Mathematics, 99*(5), 258-271.

Loucks-Horsley, S., Stiles, K., & Hewson, P. W. (1996). *Principles of effective professional development for mathematics and science education: A synthesis of standards.* Madison, WI: University of Wisconsin at Madison, National Institute for Science Education.

Martinez, G., & Martinez, N. (1998). In defense of mathematics reform and the NCTM's Principles and Standards. *The Mathematics Teacher*, *91*(9), 746-748.

Mewborn, D. S. (2003). Teaching, teachers' knowledge, and their professional development. In J. Kilpatrick, W. F. Martin, & D. Schifter (Eds.), *A research companion to principles and Standards for school mathematics* (pp. 5-23). Reston, VA: The National Council of Teachers of Mathematics.

Murray, T. R. (1998). *Conducting educational research: A comparative view.* Westport, CT: Greenwood Group.

National Center for Improving Student Learning and Achievement in Mathematics and Science. (2002, Fall). K-12 mathematics and science: Research and implications. *Wisconsin Center for Education Research: School of Education, University of Wisconsin Madison, 2*(1).

National Center for Improving Student Learning and Achievement in Mathematics and Science. (2004, February). *Scaling up innovative practices in mathematics and science.* University of Wisconsin Center for Education Research: School of education, University of Wisconsin Madison. Retrieved October 2, 2004, from http://www.wcer.wisc.edu/ncisla

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for education reform..* Washington, DC: U. S. Government Printing Office.

National Council of Teacher of Mathematics. (1980). *An agenda for action: Recommendations for school mathematics of the 1980s.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1995). *Assessment standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author. Retrieved October 11, 2004, from http://Principles and Standards.nctm.org/document/prepost/project.html

National Council of Teachers of Mathematics. (2003). *A research companion to principles and standards for school mathematics.* J. Kilpatrick, W. G. Martin, & D. Schifter (Eds). Reston, VA: Author.

National Research Council. (1989). *Everybody counts: A report to the nation on the future of mathematics education.* Washington, DC: National Academy Press.

National Research Council. (1999). *How people learn: Brain, mind, experience, and school.* J. Bransford, A. Brown., & R. Cocking (Eds.). Washington, DC: National Academy Press.

Nelson, B. S. (1997). Learning about teacher change in the context of mathematics education reform: Where have we come from?. In E. Fennema, & B. S. Nelson (Eds.), *Mathematics teachers in transition* (pp. 3-18). Mahwah, NJ: Lawrence Erlbaum.

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*(4), 317-28.

Office of Educational Research and Improvement (ED). (1991). Communicating the next Message of reform through the professional Principles and Standards for teaching mathematics. *ERIC/SMEAC Mathematics Education Digest*. Retrieved July 7, 2004, from http://www.edrs.com/members/sp.cfm?AN=ED335238

Pajares, M. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

Pligge, M. A., Kent, L. B., & Spence, M. S. (2000). *Examining teacher change within the context of mathematics curriculum reform: Views from middle school teachers*. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Remillard, J. T., & Bryans, M. B. (2004). Teachers' orientations toward mathematics curriculum materials: Implications for teacher learning. *Journal for Research in Mathematics Education, 35*(5), 352-388.

Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula, T. J. Buttery, & E. Guyton (Eds.), *Handbook of research on teacher education* (pp. 102-119). New York: Simon & Schuster Macmillan.

Riordan, G., & da Costa, J. L. (1998, April). *Leadership for effective teacher collaboration: Suggestions for principals and teacher leaders*. Paper presented at the Annual Meeting of the American Educational Research Association, San Diego: CA.

Riordan, J. E., & Noyce, P. E. (2001). The impact of two *Standards*-based mathematics curricula on students achievement in Massachusetts. *Journal for Research in Mathematics Education, 32*(4), 368-98. Retrieved October 9, 2004, from http://vnweb.hwwilsonweb.com.erl.lib.byu.edu/hww/results/results_single.jhtml?nn=11

Ross, J. A. (1994). The impact of an inservice to promote cooperative learning on the stability of teacher efficacy. *Teaching and Teacher Education, 10*(4), 381-394.

Rouseau, C. K. (2004). Shared beliefs, conflict, and a retreat from reform: the story of A professional community of high school mathematics teachers. *Teaching and Teacher Education, 20*(8), 783-96.

Russell, S. (1998a). *Relearning to teach arithmetic: Addition and subtraction*. Parsippany, NJ: Dale Seymour.

Russell, S. (1998b). *Relearning to teach arithmetic: Multiplication and division*. Parsippany, NJ: Dale Seymour.

Schifter, D. (Ed.) (1996a). *What's happening in math class: Envisioning new practices through teacher narratives*, (Vol. 1). New York: Teachers College Press.

Schifter, D. (Ed.) (1996b). *What's happening in math class: Reconstructing professional Identities*, (Vol. 2). New York: Teachers College Press.

Settlage, J., Southerland, S. A., & Smith, L. K. (in review). Overconfidence and the value of self-doubt: Elementary teachers' views about teaching science to diverse populations.

Shifter, D., Bastable, V., & Russell, S. (1999). *Developing mathematical ideas: Numbers and operations, building a system of tens*, (Vol. 1). Parsippany, NJ: Dale Seymour.

Shifter, D., Bastable, V., & Russell, S. (1999). *Developing mathematical ideas: Numbers and operations, making meaning for operations*, (Vol. 2). Parsippany, NJ: Dale Seymour.

Shulman, L. S. (1986a). Paradigms and research programs in the study of teaching: A contemporary perspective. In M. C. Whittrock (Ed.), *Handbook of research of teaching.* New York: Macmillan.

Shulman, L. S. (1986b). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

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

Sirotnik, K. (1999). Making sense of educational renewal. *Phi Delta Kappan*, *80*(8) 606-610.

Smith, L. K. (1995). The impact of early life history on teachers beliefs: In-school and out-of-school experiences as learners and knowers of science. *Teachers and Teaching: Theory and Practice, 11*(1), 5-36.

Stake, R. E. (1988). The case study method in social inquiry. *Educational Researcher, 7*(2), 5-8.

Stake, R. E. (1993). Description of the research project. In R. Stake, T. Denny, G. Hoke, J. Easley, D. Jenness, M. Miron, & B. Metcalf (Eds.), *Teacher preparation archives: Case studies of NSF-funded middle school science and mathematics teacher preparation projects* (pp. 1-16). Urbana IL: Center for Instructional Research and Curriculum Evaluation.

Stake, R. E. (1995). *The art of case study research.* Thousand Oaks, CA: Sage.

Stein, M. K., & Wang, M. C. (1988). Teacher development and school improvement: The process of teacher change. *Teaching and Teacher Education, 4*(2), 171-187.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory.* Thousands Oak, CA: Sage.

Swars, S. L. (2005). Examining perceptions of mathematics teaching effectiveness among elementary preservice teachers with differing levels of mathematics teacher efficacy. *Journal of Instructional psychology, 32*(2), 139-47.

Technical Education Research Centers (1998). *Investigations in number, data, and space*. White Plains, NY: Dale Seymour.

Thompson, A. (1984). The relationship of teachers' conceptions of mathematics teaching to instructional practice. *Educational Studies in Mathematics. 15,* 105-127.

Thompson, A. (1992). Teachers' beliefs and conceptions: A syntheses of the research. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 127-146). New York: Macmillan.

Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive Construct. *Teaching and Teacher Education, 17*(7), 783-805.

Van Manen, M. (1994). Pedagogy, virtue, and narrative identity in teaching. *Curriculum Inquiry, 24*(2), 135-170.

Verma, G. K., & Mallick, K. (1999). *Researching education: Perspectives and techniques.* Philadelphia, PA: Falmer Press.

von Glasersfeld, E. (1988). The reluctance to change a way of thinking. *The Irish Journal of Psychology, 9*(1), 83-90.

Warfield, J., Wood, T., & Lehman, J. D. (2005). Autonomy, beliefs and the learning of elementary mathematics teachers. *Teaching and Teacher Education, 21*(4). 439-56.

Weasmer, J., & Woods, A. M. (1998). I think I can: The role of personal teaching efficacy in bringing about change. *The Clearing House, 71*, 245-247. Retrieved January 15, 2005, from http://wf2la2.webfeat.org/WprpC1142/url= http://vnweb.hwwilsonweb.com/hww/results

Wheatley, K. F. (2002). The potential benefits of teacher efficacy doubts for educational reform. *Teaching and Teacher Education, 18*, 5-22.

Wood, T., Cobb, P., & Yakel, E. (1991). Change in teaching mathematics: A case study. *American Educational Research Journal, 28*(3), 587-616.

Yin, R. K. (1994). *Case study research: Design and methods.* Thousand Oaks, CA: Sage Publications.

APPENDIXES

APPENDIX A

Teacher Consent Form

CONSENT TO ACT AS A RESEARCH PARTICIPANT

Change in mathematics beliefs: A look at a collaborative study group

PURPOSE OF STUDY:

You have been selected to participate in a research study. This study is designed to examine the experience of a collaborative professional development study group focused on *Standards*-based mathematics in relation to mathematics teaching efficacy changes. Kerri Hundley, a graduate student at Brigham Young University, will act as participant researcher. She will be involved in facilitating and analyzing discussions, interviews, e-mail correspondence, personal mathematics histories, and response journals in order to examine the experiences you have and your knowledge and beliefs about *Standards*-based mathematics instruction.

PROCEDURE:

For the purposes of this study you will be asked to do the following:

1. Write a brief personal mathematics history.
2. Participate in 8-10 bi-weekly, 2-hour meetings for instruction and discussion, which will be audio-taped.
3. Read research articles and apply new learning in my classroom.
4. Write in a reflective journal at the end of each meeting.
5. Participate in 3 personal interviews, lasting no longer than 1 hour, which will be audio-taped.
6. Participate in 2-3 Mathematical Teaching Efficacy Beliefs Instruments, to be completed on line.
7. Respond briefly to occasional e-mail prompts.

Your participation in this study is completely voluntary and that you may refuse to answer any question posed to you at any time. Data collection from the study will only be used for research purposes.

DURATION:

Meetings and interviews will be held at a time and place convenient to you. Meetings will last no longer than two hours and interviews no longer than one hour per session. The study will last seven months.

CONFIDENTIALITY:

Although it is possible that you might be identifiable through these descriptions, efforts will be made to preserve your anonymity. The names of other school personnel, the school, the district, and the state will remain confidential and will not be revealed in the rough transcripts of the interviews or in published results of this study.

To minimize identification, all participants will be given a pseudonym and all information regarding participation will be designated by the preferred name or pseudonym. The key of names and pseudonyms will be kept in a secure and confidential place by the researcher and will not be made available to outside agencies or persons at any time.

RISKS AND DISCOMFORTS:
The researcher anticipates that your participation in this study will result in minimal personal risks. These would include only those inherent to reflection on your own practice. The district has been informed of the research being conducted, and the superintendent's executive staff has granted district approval. The nature and content of your comments offered through personal interviews, meetings, and instruments will not be revealed to school or district administration, and your participation or refusal to participate in the research will not impact your employment status in any way. Steps have been taken to ensure participant confidentiality (see above) and research has been designed to minimize the chance of any personal risks.

BENEFITS:
Your participation in this study may result in 1 credit to be applied to state lane change at your request. It is not required to apply for credit in order to participate in the study. Any other benefits are the implicit benefits of reflection on your own beliefs and practice. You will also be allowed to read the initial draft of the findings in order to clarify interpretation by the researcher, and the findings of this study will be revealed to you at the conclusion of the research project.

WITHDRAWAL:
Your participation in this study is completely voluntary. Thus, you may refuse to participate in any part of the research, or withdraw from the study at any time, simply by informing the researcher. Even if you agree to participate in the research efforts, it is your right to refuse to answer any interview or instrument question asked of you at any time.

CONCERNS:
You can ask questions regarding this research at any time. You may reach the researcher, Kerri Hundley, at (801) 756-7756 or e-mail hund183@alpine.k12.ut.us. You may reach her advisor, Leigh Smith, Brigham Young University, Department of Teacher Education, at (801) 422-1947. In the case of injury, breach of confidentiality, or other concerns that you feel you cannot safely discuss with the researcher or her advisor, you can contact Dr. Renea Beckstrand, IRB Chair, at 422-3873, 422 SWKT or renea_beckstrand@byu.edu.

CONSENT
Signing this document signifies that you have read and understood the above consent information and agree to participate in this study. You also acknowledge that you have received a copy of this consent form.

Print Name: ____

Signature: ____

Date: ____

APPENDIX B

Personal Mathematics Critical Events Timeline

Think about the critical events in your life that influenced your feelings and beliefs about mathematics and mathematics education. Please record each critical event in the left-hand column with the approximate year. Then explain how or why each event affected your mathematics beliefs in the right-hand column. You may write on the back on this page if needed

Year: Event: Year: Event: Year: Event: Year: Event:	

APPENDIX C

Sample Interview Questions for Participants

Interview 1

1. Describe your mathematics instruction. How do you teach mathematics?

2. Describe your best mathematics lesson.

3. How would you respond in the following situation:

   Students are working in groups to solve a mathematics problem. It appears to you that one student is doing all the work while the others are missing out on some key understanding.

4. What personal experiences have you had that have influenced your feelings about math?

5. What do you think our professional study group should look like in terms of learning, discussion, etc.?

6. What would you like to see happen as a result of your participation in this study group?

7. What do you see as your role in the study group?

8. What do you see as my role in the study group?

APPENDIX D

Sample Interview Questions for Participants

Interviews 2 and 3

1. What have you liked about the study group so far?
2. What would you change about the study group?
3. How do you feel the group could better meet your needs in implementing *Investigations in Number, Data, and Space* or *Connected Mathematics Project* in your classroom?
4. What mathematical understandings have you gained from your participation in the study group?
5. Have your feelings about *Standards*-based mathematics changed since your involvement in the study group? If so, how?
6. Have your feelings about your ability to successfully implement *Investigations in Number, Data, and Space* or *Connected Mathematics Project* changed since your involvement in the study group? To what do you attribute this change?

APPENDIX E

Sample Group Meeting Format

Lesson Portion

1. View videotape included with the instructional materials from RTAAS (Russell, 1998a) or RTAMD (Russell, 1998b) of children solving mathematical problems. Think about how you would solve the same problems. Analyze what the children are thinking about as they solve the problems. What role is the teacher playing in the video?
2. Discuss the video focusing on your own and the children's thinking. Try to solve new problems using the strategies that the children developed. Compare the strategies for similarities and differences. What is it that the students know? What concerns or questions to you have about the children's learning or your own thinking?
3. Assignment of next reading will be given.

Discussion Portion

1. Discuss any successes, epiphanies, questions, concerns, frustrations. Brainstorm applications, connections, solutions. You may refer to mathematical histories, reflection journals, or e-mail communications.
2. Discuss insights and questions from last session's reading selection.

APPENDIX F

Schedule of Interviews and Study Group Meetings

SCHEDULE OF INTERVIEWS AND STUDY GROUP MEETINGS

Date	Interview or Meeting	Participant
September 12	Contact Study Group Assign Mathematics Critical Events	All Participants
September 16	Critical Events Due	All Participants
September 19	Interview	Participant 1 Participant 2
September 20	Interview	Participant 3 Participant 4
September 21	Interview	Participant 5 Participant 6
September 26	Meeting	All Participants
October 10	Meeting	All Participants
October 24	Meeting	All Participants
November 7	Meeting	All Participants
November 14 Or Dec. 5	Meeting	All Participants
November 15	Interview	Participant 1 Participant 2
November 17	Interview	Participant 3 Participant 4
November 18	Interview	Participant 5 Participant 6
January 9	Meeting	All Participants
January 23	Meeting	All Participants
February 6	Meeting	All Participants
February13	Interview	Participant 1 Participant 2
February 16	Interview	Participant 3 Participant 4
February 17	Interview	Participant 5 Participant 6