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THE RELATIONSHIPS BETWEEN TEACHERS' EFFICACY BELIEFS AND REFORM-ORIENTED MATHEMATICS TEACHING: THREE CASE STUDIES

By

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ABSTRACT

THE RELATIONSHIPS BETWEEN TEACHERS' EFFICACY BELIEFS AND REFORM-ORIENTED MATHEMATICS TEACHING: THREE CASE STUDIES

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Past reform efforts in mathematics education have often had only a modest impact on teaching. Teachers' efficacy beliefs have been related to their adoption of reform-oriented practices. However, the current mathematics reforms may threaten teachers' efficacy beliefs in various ways. For the reforms to succeed, teachers need to find ways to feel efficacious when teaching mathematics in reform-oriented ways. This study examined the relationships between elementary school teachers' efficacy beliefs and their attempts to teach mathematics in reform-oriented ways.

The three teachers taught in an urban school district in California. From 1991 through 1995, I made two field visits each year to observe and interview the teachers. Observations focused on each teacher's mathematics teaching. I interviewed the teachers extensively regarding their teaching context, mathematics teaching, knowledge and interpretation of the reforms, and their efficacy beliefs regarding mathematics teaching.

Three case studies illustrate the ways that these teachers varied in mathematics teaching, knowledge and interpretations of the reforms, enthusiasm for the reforms, and their efficacy beliefs. Only one teacher found substantial support for her feelings of efficacy when using reformed teaching methods. Individual and social factors influenced the teachers' use of reformed practices and their efficacy beliefs. Teacher knowledge and interpretations, teaching resources, time and collaboration were crucial issues in the degree to which teachers were successful in using reformed practices.

Several themes emerged across the cases. First, in the most successful case of reformed mathematics teaching, intrinsic motivation and self-regulation characterized teacher and student engagement. Second, feelings of efficacy regarding reformed teaching were related to a teacher's interpretation that reformed teaching involves an active role for teachers and students, and an interweaving of new and traditional elements of teaching. Third, the most successful teacher expressed an interdependent sense of efficacy--an interpretation that educational outcomes are constructed together with students, parents and others.

Based upon these case studies, I discuss the value of gathering interpretive data regarding teachers' efficacy beliefs. I propose a new model of teachers' efficacy beliefs, emphasizing teachers' interpretations and social interactions. Finally, I discuss implications of these cases for reformers and researchers.

For My Parents and Amy

ACKNOWLEDGMENTS

My appreciation goes first to the three teachers whose stories are told in these pages. Their willingness to participate in this study reflected their desire to contribute to research that would benefit students and other teachers in the future. Each teacher made an important contribution to my attempt to better understand efficacy beliefs and reform-oriented teaching. I thank them for their time, interest, and patience with the research process. I would also like to thank the administrators who made it possible for me to conduct research in their schools and whose comments provided crucial contextual data for my study.

My study was part of a larger research project—the Educational Policy and Practice Study (EPPS). The project's principal investigators, Penelope Peterson, Deborah Ball, David Cohen and Suzanne Wilson, provided me with the opportunity to be part of a large community of researchers working together to study important issues in the field of educational policy and practice. I benefited greatly from my participation in the EPPS project.

I appreciate the interest that the members of my dissertation committee--Carole Ames, Deborah Ball and Dick Prawat--have shown in my work. Their constructive feedback was extremely helpful in the completion of this dissertation.

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Finally, I would like to thank my wife Amy, my parents Ira and Alice Wheatley, my father- and mother-in-law David and Pearl Powell, and my sister Krista Wheatley-Heckman, for their unwavering love and support.

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Chapter One

INTRODUCTION TO THE STUDY

I have been interested in many of the issues this study addresses since the early 1980s. I experienced both struggle and success in teaching teenagers and preschoolers using a "progressive" approach to education. By the mid-1980s, I was directing an arts and sciences camp for gifted and talented teenagers, and traveling around the country conducting workshops on early childhood education. Both roles found me trying to help others to teach in more progressive ways. Success was never certain nor easy in any of these endeavors, and I became interested in the processes of individual and organizational change.

Beginning doctoral work in educational psychology at Michigan State University in 1991, I noted on my goal statement my interest in educational reform and the relationships between motivation and learning.

My research assistantship at MSU gave me the opportunity to work with a large team of faculty and graduate students on the Educational Practice and Policy Study (EPPS), studying ambitious efforts at educational reform in reading and mathematics. This experience broadened my understanding of issues of elementary education and subject matter teaching and learning, and was the context in which I conducted this study.

I discuss four topics in this chapter: the reforms in mathematics, how my research focus for this study emerged, the ways in which efficacy beliefs and efforts at reform-oriented mathematics teaching might be related, and my purpose and methods for conducting this study.

Recent Reforms in Mathematics Education

There have been waves of recent reform efforts in mathematics education in the United States. In 1980, the National Council of Teachers of Mathematics (NCTM) published "An Agenda for Action," calling for mathematics education to focus greater attention on student engagement in problem solving and in learning how to reason about mathematics. During the 1980s, other national reform efforts emerged, and NCTM published the "Curriculum and Evaluation Standards for School Mathematics" (1989) and the "Professional Standards for Teaching Mathematics" (1991).

The vision found in these documents suggests numerous specific changes from traditional views of mathematics and of mathematics teaching. In this new vision, the central goal of school mathematics is that students develop "mathematical power," which is defined as students' ability to "explore, conjecture, and reason logically, as well as the ability to use a variety of mathematical methods effectively to solve non-routine problems" (NCTM, 1989, p. 5). The definition of mathematical power found in the Standards indicates that doing mathematics involves dynamic and integrative activities, and thus, is far more than a set of static skills and concepts to be mastered (Romberg, 1995).

For many educators, the reforms suggest a variety of substantial changes. These include changes in thinking about what mathematics is, how it changes as a field, what mathematics is most important to learn, when students can learn particular aspects of mathematics, how students learn math, and what the teacher's role is in helping students learn (Cohen & Ball, 1990a; Remillard & K. Wheatley, 1994). Regarding mathematics practice, these reforms suggest a decreased emphasis on computation-oriented exercises; increased emphasis on non-routine problem-solving, on mathematical discourse, and on the relatedness of mathematical topics; increased use of calculators and manipulatives; and the introduction of concepts such as probability and algebra in elementary grades. The reforms suggest that the teacher's role should shift from the traditional teaching-through-transmission model (Cobb, 1988). In reform-oriented teaching, students take a much more active role in their own learning, as the teacher becomes a guide and facilitator of student growth (Romberg, 1995; Zollman & Mason, 1992). Teachers are expected to create problem-solving situations which foster cognitive reorganization of students' thinking about mathematics (Schifter & Fosnot, 1993).

Reform Efforts in California

California's reform efforts in mathematics education developed simultaneously with the national reform efforts. California launched a major effort in the mid-1980s to reshape what mathematics was taught in the state, and how it was taught. The California Department of Education (CDE) published a new state mathematics framework (CDE, 1985) and model curriculum guides (CDE, 1987). They continued this reform effort by updating the state mathematics framework (CDE, 1992) and by publishing documents reflecting changed visions of mathematics assessment (CDE, 1989). The reform-minded purpose of California's Department of Education is clear in these documents, in statements such as, "Open-ended questions in mathematics (those requiring a written response, as opposed to multiple choice) have the potential to drive curriculum in positive directions sought by leaders in education" (CDE, 1989, p. v). The overall direction of these reforms is toward "teaching for understanding." The state hopes to arrive at a point where the texts, teaching, and tests are all aligned toward this common vision (Grant, Peterson, & Shojgreen-Downer, 1994).

More specifically, the 1992 California Mathematics Framework explains that its purpose is to reinforce the "momentum toward reform," at a time "in which the national mathematics community reached an unprecedented degree of consensus" (p. ix).

Consistent with the NCTM Frameworks, the 1992 California Mathematics Framework stresses the goal of mathematical power "for all students" as central to the purpose of mathematics education. The 1992 framework explains that mathematically powerful students use mathematical ideas, mathematical thinking, communication, and mathematical tools and techniques. They do this while working individually and collaboratively, appreciating the history of mathematics and its relationships to society, and while developing confidence and a positive disposition toward mathematics.

On the face of it, one could interpret mathematical power as being little different than the outcomes of traditional mathematics curriculum, with the attention to history and development of a positive disposition towards mathematics being the only new features. However, a closer look at just one aspect of mathematical power, mathematical thinking, reveals some of the significant ways in which the reforms depart from traditional mathematics education. The framework explains that mathematical thinking involves higher-order thinking. In turn, higher order thinking is described as being nonalgorithmic, meaning that the necessary "action is not fully specified in advance" (p. 21). This contrasts with the emphasis on learning and applying pre-specified algorithms that is found in traditional mathematics education. Contrasting with the emphasis on certainty and single correct answers found in traditional practice, the framework suggests that higher order thinking in mathematics often yields multiple solutions and often involves uncertainty.

While traditional practice was characterized by teachers tightly controlling and directing students' activity, the framework explains that higher-order thinking involves students' "self-regulation" of their own thinking and learning.

Beyond these changes, the framework calls for other changes teaching methods. These include increased use of tools such as manipulatives, calculators and computers for learning mathematics. There is also an increased emphasis on having students explain their thinking and problem solving, while teachers explore in depth students' conceptual understanding. The framework calls for developing deeper student understandings of patterns and relationships in mathematics. It suggests a more democratic classroom climate, where students play a more active role in their own learning than is common in traditional practice. In such a climate, authority for mathematical truth resides in logical reasoning and argumentation regarding mathematics, rather than in the unquestioned authority of the teacher or the texts (National Research Council, 1990). The reforms suggests moving away from focusing directly on teaching discrete mathematical facts and skills in a "logical" sequence, during brief self-contained lessons. Instead, they suggest teaching concepts and skills in the context of students' ongoing problem solving and explorations. Unlike the computation problems that constituted "problem-solving" in earlier years, these reforms suggest that mathematics teaching and learning may often involve problems that students and teachers have to wrestle with over a period of days.

The 1992 California Mathematics Framework also calls for changes in mathematics curriculum, and stress how the suggested changes fit squarely with the recommendations of NCTM's 1989 Curriculum and Evaluation Standards for School Mathematics. The curriculum suggested by the framework emphasizes "large mathematical ideas and their interconnections" (p. 76), and is organized around a set of mathematical strands and unifying ideas. The strands are functions, algebra, geometry, statistics and probability, discrete mathematics, measurement, number and logic and language. The unifying ideas include some of the "big ideas" in mathematics, ideas, which cut across the strands, such as patterns, algorithms, and proportional relationships.

Constructivism and Students' Learning

At heart, the reforms at the national level and in California are based on ideas about constructivism--the theory that learners actively construct their own understanding of subject matter, rather than having it simply transmitted to them by teachers, and "seeing" or "grasping" the mathematics that the teacher has transmitted. The theory of constructivism is at odds with more traditional approaches to teaching, such as direct instruction (Cobb, 1988; G. H. Wheatley, 1994). "Constructivism challenges the assumption that meanings reside in words, actions, and objects independently of an interpreter" (Cobb, 1988, p. 88). The view that mathematics cannot simply be "made clear" to students, and transmitted to them in a way that they are able to readily absorb the intended meaning is supported by research into student misconceptions (e.g., Confrey, 1990). Most notably, this research has found that deep misconceptions and lack of understanding regarding subject matter can be found in students who can carry out procedures and algorithms accurately. Even in classrooms in which the teachers' traditional teaching could be characterized as "effective teaching" as seen from the process-product tradition, students sometimes lack understanding, and acquire perspectives that may have be obstacles to future learning (e.g., Schoenfeld, 1988). The reforms cite such research to suggest that procedural fluency is not enough. That is, students need to develop a deep understanding of the concepts underlying the mathematical procedures they are doing, and the ability to "do mathematics" in meaningful contexts.

For its part, social constructivism suggests that the learning of mathematics is in part "a process of enculturation into the practices of intellectual communities" (Cobb, 1994). This perspective on education further complicates the teacher's role, requiring them to construct classroom communities in which teachers and students do mathematics together, and negotiate the meanings of mathematics.

New Visions of Teaching

These reforms suggest that teaching must be responsive to how students have constructed and are constructing their understanding of mathematics, and that no standard, predetermined teaching sequence represents optimal teaching. Teachers are expected to develop their own understanding of how students are making sense of mathematics, so as to be better able to extend and deepen the students' understanding. There is some evidence that greater teacher knowledge of students' knowledge and students' approach to mathematics problem-solving is associated with student achievement (e.g., Peterson, Carpenter, & Fennema, 1989).

By redefining mathematics and the goals and methods of mathematics teaching, the reforms suggest changes in how student outcomes and teacher effectiveness are to be defined, understood, and assessed (Ball, 1994; Romberg, 1993). However, the reforms may be more specific about the approach to teaching they oppose, and about the student outcomes they consider desirable, than they are about the approach to teaching they favor. Ball (1992) noted that the NCTM Standards were intended to provide guidance, but that, by their nature they cannot really dictate or prescribe teaching practices. Along similar lines, Cohen and Ball (1990b) argue that the California mathematics reforms are ambitious, but that they are vague--open to multiple interpretations. They note that this has allowed many to embrace the reforms, but how the reforms are interpreted and implemented varies widely.

The Cultural Context of the Current Reforms

The recent reforms in mathematics education were created during a period of great national disenchantment with the American educational system, and great concern about studies suggesting that American students are "behind" those of other countries (Berliner

& Biddle, 1995). The issue of whether American students are lagging behind those of other countries is of even greater significance given the increasingly global economy. In centuries past, when cognitive ability was largely produced and consumed locally, concern about the success of education was largely related to the cognitive demands of tasks carried out in the local community, and one's place in that community. With an increasingly global economy, concern about relative cognitive ability relates to suggestions that entire countries that fall behind cognitively may subsequently fall behind economically. At least within the United States, there is evidence to suggest an increasingly strong connection between cognitive ability (using IQ measures) and an individual's occupational and economic status (Herrnstein & Murray, 1994).

Cultural Sea Changes Supporting the Reforms

Along with these national concerns about cognitive and economic competitiveness, there has been a shift in the types of knowledge and skills that the business community says workers need. Major employers suggest that workers in today's world need more advanced skills, problem-solving skills, and the ability to work well with others. The focus on such skills is congruent with many of the educational outcomes emphasized in the current mathematics reforms.

The reform movement's emphasis on teaching for understanding is also supported by "sea changes" in education, psychology, and in views of the nature of science itself. As psychology moved from a behavioral to a more cognitive orientation (Hunt, 1993), research into student outcomes in mathematics other than procedural fluency and recitation of math facts was legitimized. Further, as thinking became a legitimate object of research interest, teachers and reformers could more easily argue that students' understanding of ideas mattered as an educational outcome. Once analysis of cognitions was legitimized, researchers began to find evidence of deep misconceptions of subject matter by students--even by those who could carry out the procedures accurately (e.g., Confrey, 1990; Merseth, 1993).

Such findings provided further impetus for the emphasis on conceptual understanding as a central educational outcome. Moreover, conceptions of the nature of science itself have changed--moving towards a view that science is significantly influenced by human beliefs, desires, interpretations, and interactions (Kuhn, 1962). Such a view of the nature of science is more congruent with the view of mathematics that the reformers offer than is a positivist view. The positivist view characterizes mathematics as a static field of study in which there are a large number of objective facts that need to be internalized by students.

Mathematics Learning as a National Goal

In this broader climate of concern, reform, and changing worldviews, mathematics has received special attention from policymakers and reformers. For example, in 1990, President George Bush announced as one of his goals for education that by the year 2000, American students would rank first in the world in science and mathematics. The proposal of such ambitious national goals for education has occurred at a time in which the federal education establishment has gained power, prestige, and influence (Cohen, 1995).

All of these features of the current situation in the United States seem to provide reason for optimism regarding the success of the current reforms in mathematics. Improvement in mathematics performance is seen as a crucial national goal, and the current reforms seem congruent with the current popular general view of science, and with recent approaches to, and results of, educational research. Furthermore, the current reforms have centered on standards, which were not proposed by outsiders, but by a well-respected national organization of teachers of mathematics (i.e., NCTM). Despite the weak track record of past reforms, Hatfield and Price (1992) suggest that because of the broad base of support for these reforms, “The chances are better than even that the needed reforms will take place” (p. 34).

Nevertheless, the current reforms face various obstacles. These obstacles include societal beliefs, the typical curriculum in schools, and teacher preparation (Merseth, 1993).

Societal beliefs in the United States have tended to be that math is about rules, that the content of math is fixed, and that success depends on ability (Sarason, 1971). Thus, changing the public's philosophy and beliefs regarding school mathematics is one necessary ingredient for the reforms to be successful (National Research Council, 1990). Also, Merseth and others characterize the typical curriculum in schools as outdated, textbook-driven, involving a misuse of spiral curriculum, and emphasizing procedural fluency, not understanding. Regarding teacher preparation, Merseth notes that teachers didn't learn the mathematics called for by the reforms nor did they learn it this way, and they tend to lack subject-matter depth. Jones (1995) reminds us that teachers who lack deep knowledge of mathematics are more likely to use traditional, rote methods. Brown and Borko (1992) point out that "teaching for understanding" is impossible for those who themselves lack conceptual understanding of mathematics. As another obstacle, teachers' ideas about discipline and control often conflict with the types of interactions and the social organization of activities that are called for by reforms (Gregg, 1995). Since one's ability to control one's class is often a key criterion by which teachers are judged, teachers may reflexively gravitate towards a more traditional model of mathematics teaching. Finally, any educational movement that is national in scope may face opposition simply because of the recent resurgence in politics of a strong desire for local control, and a "devolution" of control of education from the federal level to the state and local level.

Past Efforts to Reform Mathematics Education

Past educational reform efforts in the United States suggest how complicated educational reform is, and how strong support for reform at the national level can translate into little or nothing happening at the local level.

The mathematics reforms of the 1960s had a great deal working in their favor. They were aimed at enhancing students' understanding of mathematics, and at helping them learn mathematics in a way that was similar to how mathematicians work and how mathematics is used in science (Wojciechowska, 1989). These reforms came about in an era of growing confidence in the ability of the federal government to effect local changes.

Fueled by cold-war fears of Soviet technological and military superiority, the reforms were created and supported by national leaders in education, psychology, science, and politics (Welch, 1979). They received some of the first large-scale federal funding available for education, and yet, they had only a modest impact on educational practices.

Optimism Lost, Wisdom Gained

Learning that implementing comprehensive educational reform was not as straightforward as building the interstate highway system nor as putting a man on the moon, educational policy researchers began to wonder what went awry. One discovery about these educational reform efforts, and similar national reforms in social services, was that "front-line" workers played a major role in ignoring, enabling, and interpreting policies created in far-away places. Attention began to focus on the role of these "street-level" bureaucrats, people who mediate between policies and real-world clients, in real-world situations (Lipsky, 1980).

The Central Role of Teachers in Reforms

A multitude of findings confirmed the pivotal nature of the teacher's role in shaping and determining the fate of policies. Findings contradicted the assumption that teachers would simply "implement" the curriculum they were provided with (e.g., Stake & Easley, 1978). Instead, when teachers' or parents' beliefs or goals conflicted with the reforms, the reforms were often modified or ignored (Wojciechowska, 1989). Thus, while teachers are acknowledged as the ones who must ultimately translate policy into practice, they are also seen as obstacles in the way of getting policies into place (Prawat, 1992). The success of reforms often pivots on whether teachers will help or hinder the reform effort, and the many possible reasons behind their actions. For these reasons, what teachers think, know and feel has become interesting to educational policy researchers--in no small part because it is crucial for what happens with efforts to reform education.

Therefore, research has shifted to focus on the characteristics of teachers' mental lives that were associated with desired outcomes. In recent years, the literature on teacher change has consistently highlighted the importance of teacher thinking for what happens with reform efforts (e.g., Putnam, Heaton, Prawat & Remillard, 1991).

Teacher knowledge. One fundamental issue for educational policy concerns teacher knowledge in relation to the demands of reforms: "How can teachers teach a mathematics they never learned, in ways that they never experienced" (Cohen & Ball, 1990a, p. 238). This has been a persistent dilemma for policy and practice. Teachers lack the knowledge required by the reforms, and they also don't have adequate learning opportunities to help them understand new ways of teaching and learning. In research on the mathematics reforms of the 1960s, Sarason (1971) found that staff development programs that told teachers to teach in new, non-traditional ways were themselves examples of very traditional practice. Cohen (1990) reports that the same problem persists--the pedagogy of the current reforms does not match the approach to teaching suggested in the reforms. Reformers are telling teachers to do less of their teaching by telling. Thus, it is not surprising that early studies on the reforms found that even teachers who considered themselves to be teaching in reform-oriented ways often used a mixture of traditional and reform-oriented practices (e.g., Cohen, 1990; Peterson, 1990a).

Teacher motivation. Another fundamental policy issue has to do with teachers' motivation to engage in reform-oriented practices. For example, Elmore (1996) cites research suggesting that even in the most successful periods of educational reforms, only about twenty-five percent of teachers have changed their instruction. He concludes from this finding that we need to find better ways to motivate teachers (and others) to attempt and persist at reform-oriented teaching. Many others have recently taken up the discussion of how to better motivate teachers to engage in reform-oriented teaching (e.g., Fuhrman & O'Day, 1996). Many of the suggestions being forwarded depend on various incentive plans, such as merit pay for teachers (e.g., Odden, 1996). However, even ambitious attempts to create merit pay plans for teachers have often worked poorly in the past, and Cohen (1996) points out the great tangle of considerations which have to be sorted through to design a merit pay plan that even seems sensible on paper. While efforts to better motivate teachers through merit pay may have an uncertain future, research into another aspect of teacher motivation has already been quite fruitful. Teachers' efficacy beliefs are one aspect of teacher motivation that has been linked to adoption of educational innovations and associated with a variety of teaching practices related to current reforms.

The role of efficacy beliefs in reformed teaching. Of importance for a reform movement, teachers' efficacy beliefs--the extent to which teachers believe that they have the capacity to impact student performance--have been linked to the adoption and use of innovative educational practices. In one study by the Rand Corporation, a strong positive relationship was found between teachers' efficacy beliefs and several variables: the extent of teachers' change in educational practices, improved student achievement, and the maintenance of the innovative educational practices by teachers (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977). The focus of this study was on changing educational practices, and Berman et al. concluded that "teachers' attitudes about their own professional competence, in short, appear to have major effects on what happens to projects and how effective they are" (p. 137). Summarizing the findings of the series of related Rand studies, McLaughlin and Marsh noted that teachers' sense of efficacy was "the most powerful teacher attribute in the Rand analysis" (1978, p. 84). This was a major finding at the time, since previous efforts to find relationships between teacher attitudes and student achievement had yielded little (Dunkin & Biddle, 1974; Getzels & Jackson, 1963). More recently, teachers' efficacy beliefs have been found to be an important predictor of teachers' adoption of educational innovations. As Smylie (1988) explains, "The findings from the path analysis suggest that, in the absence of organizational foci and pressures for change associated with school or district innovation, individual change is a direct function of personal teaching efficacy" (p. 1). Smylie explains that it makes more sense for a teacher to change their behavior in ways that might improve their effectiveness in the classroom if they believe that their actions "are instrumental to the learning of their students" (p. 23). These findings and others suggest that teachers' efficacy beliefs may play an important role in their adoption of and persistence with reformed practices.

Will the reforms undermine teachers' sense of efficacy? There is another side of the issue here. The reforms, specifically the mathematics education reforms, may have effects on teachers' efficacy beliefs. Teachers used to teaching mathematics in traditional ways may feel less effective when trying to teach in new ways, and when teaching new mathematical content. Teachers may come to believe that they cannot help students learn, or at least that they cannot help them learn as well when using reform-oriented teaching practices. If this were to occur, this would be a crucial problem for the reforms, given the importance to teachers of feeling that they have a positive impact on students.

Making a difference matters to teachers. Believing that they can impact students is crucial to teachers (Ashton, 1985; Lortie, 1975), and having an impact on students is a centerpiece of teachers' motivation to teach. Teachers tend to cite intrinsic motives as the most important reason for becoming and remaining a teacher (Rosenholtz, 1989). That is, they report that they find it intrinsically rewarding to make an impact on students' lives--to experience efficacy. The significance of these feeling of efficacy is highlighted in a rare qualitative study of teacher motivation (Sederberg & Clark, 1990), which examined exemplary teachers' motives for teaching:

> The most compelling motivational theme, the raison d'être among high vitality teachers, was to play a significant and enriching role in students' lives by imparting knowledge, developing skills, increasing understanding, and helping resolve life adjustment problems. The intensity of their voices and body language when they related anecdotes about successes with students communicated the special status of these intrinsic motivations. (p. 8)

McLaughlin found that the most powerful rewards for teachers to be involved in an ambitious project aimed at changing teaching were related to their belief "that they would grow professionally and that their students would benefit" (1991, p. 64).

Since having an impact on students is so important to teachers, the future may be dim for any reform movement that threatens teachers' belief that they can have an impact on students. If teachers don't believe they can impact students when using reformed practices, the crucial loss of perceived efficacy could lead them to retreat from the reforms, or to not attempt reformed teaching at all. Moreover, teachers may react against the reforms because the reforms can be seen as implicitly or explicitly devaluing teachers past accomplishments with students.

Studying Teachers' Efficacy Beliefs in the Context of the Reforms

The relationships noted above between teachers' efficacy beliefs, educational reforms, and the use of reform-oriented practices informed my choice of a research focus for this study. I chose to study elementary teachers' efficacy beliefs in relationship to their attempts to use reform-oriented mathematics practices. In conducting this study, I focused primarily on three types of beliefs. First, I focused on what Bandura (1977) calls outcome expectancies--beliefs about the effects of particular actions or events in particular situations. If a teacher doesn't believe that third grade students learn mathematics from using manipulatives, she has negative outcome expectancies regarding the effect of manipulatives on students' learning. Second, I focused on personal mathematics teaching efficacy--the degree to which a teacher feels she can impact students' motivation or learning in mathematics. Asking directly about the teachers' perceived capacity to impact students is consistent with the approach used in the Rand studies, which were based on the concept of locus of control in Rotter's social learning theory (1966). Third, I focused on teachers' self-efficacy beliefs, as defined in the narrower sense in Bandura's social learning theory (1977). That is, I focused on teachers' beliefs that they could execute particular teaching acts called for by the reforms in mathematics education.

I discuss my research methods at the end of this chapter, but I turn next to examining important relationships between reform-oriented mathematics teaching and teachers' sense of efficacy.

The Mathematics Reforms and Teachers' Efficacy Beliefs: Friends, Foes, or Strangers?

Potential Threats to Teachers' Sense of Efficacy

As others have argued (e.g., Smith, 1996), the current reforms in mathematics can be interpreted as calling for such fundamental changes that they may threaten teachers' existing sources of positive efficacy beliefs. These potential threats to teachers' efficacy beliefs are both numerous and serious. The impact of the reforms may be seriously limited by the threat the new practices pose to efficacy beliefs, particularly if new grounds for feeling efficacious when teaching in reform-oriented ways are not found. However, the reforms may also provide opportunities for teachers to feel effective in new ways, and about different student outcomes.

I examine below various issues that the mathematics reforms raise for teachers' sense of efficacy.

The General Nature of the Reforms

First, the mathematics reforms are multifaceted, and Cohen and Ball (1990b) note that they are vague enough so that teachers may be left struggling, unsure of when they are really doing it right, and of how they would measure their effectiveness. This may pose a threat to feelings of efficacy, but the multifaceted nature of the reforms means that there are various elements that teachers can pick up on and with which they can experience some success (e.g., problem-solving, use of calculators and manipulatives). This feature of the reforms makes it more likely that teachers can find some reform-oriented practices with which they feel effective, or some goals that they can embrace.

The Nature of Mathematics

The reforms also suggest that the nature of mathematical knowledge is less certain than what most of us are accustomed to thinking. This only adds more uncertainty to an occupation where action-outcome linkages are already uncertain (Lieberman & L. Miller, 1991). This heightened uncertainty may undermine efficacy beliefs.

Moving towards a more uncertain or complex view of mathematical knowledge is a particular problem in elementary mathematics, where many teachers often don't feel confident about their grasp of even the traditional subject matter knowledge. Also, it is generally more difficult to feel highly effective when first teaching new topics, and simply by broadening the range of mathematics teachers should teach, most teachers may find it more difficult to feel mastery over the mathematics involved in the reformed teaching.

Changes in Methods

The reforms call for new teaching methods, but the reforms, by their very nature, cannot define too clearly or prescribe what the hoped-for practices are (Ball, 1994). Thus, teachers may not feel there are clear standards against which they can measure their performance, and around which they can build their feelings of efficacy.

Traditional teaching practice allowed teachers to display their knowledge to students in the process of "teaching by telling" (e.g., Smith, 1996), thus reinforcing the teachers' sense of expertise. Efficacy seems easy to see in such a model, as students reproduce facts and procedures that seemingly were "given" to them by the teacher. However, teachers with positive efficacy beliefs have been found to be less likely to simply give answers, and more likely to give students more time to figure things out on their own (Gibson & Dembo, 1984).

The broader math curriculum of the reforms makes it less likely that teachers will be able to simply turn to textbooks for guidance for all aspects of reform-oriented teaching practice. This makes such teaching more difficult, and raises the question of whether teachers will have the resources they need to feel effective with reformed teaching.

Ball (1993) says that "the reforms are attractive, but the pedagogical courses are uncertain and complex" (p. 46). She notes that authority in this type of teaching rests of mathematical argument, not on the teacher as authority, and that teachers need many resources besides knowledge for this kind of teaching, including courage. Indeed, teachers will need courage, and perhaps faith, to face the uncertainty. However, lacking a belief that such teaching will impact students' learning, or that they can teach in this way, perhaps they won't try such practices at all.

Regarding the use manipulatives to teach math, Ball (1992) argues that our hope that use of manipulatives will automatically result in deeper student understanding of mathematics is unfounded. It is significant if these outcome expectancies are overly optimistic, given the crucial role of manipulatives in how many people view the reforms. Ball cites examples from her own practice of the ways in which the meaning of both manipulatives and symbolic representations are ambiguous at times. This suggests that teacher efficacy may not always be automatically supported by the use of manipulatives, but rather, teachers will still need to travel through the potentially efficacy-threatening terrain of exploring students' partial and incomplete understandings. Talking about confidence in ways that sound very similar to efficacy beliefs, Shaw and Jakubowski (1991) note how teachers sometimes try new strategies, they don't work very well, and the teachers lose confidence in their own teaching efficacy. If using manipulatives doesn't work as well as advertised, the mismatch between experience and the optimistic rhetoric of the reforms may destroy teachers' faith in their own efficacy, or in the efficacy of reformed practices.

Finally, to the degree that teachers have in mind an oversimplified version of the reforms, they may "throw out the baby with the bath water" so to speak, abandoning entirely traditional practices that still have some merit. Along these lines, Ball and Chazan (1994) point out that some teachers interpreted the reforms as meaning they shouldn't tell students things, which left them at times with few options for helping students to learn.

The Need to Pay Attention to Learning

With the attention the reforms give to the highly individual mathematical understandings that learners construct, the reforms suggest an enormous level of teacher responsiveness to individual constructions, something that is very difficult to do. Gibson and Dembo (1984) found that teachers with more positive efficacy beliefs spent more time monitoring student work, so this may be one way in which positive efficacy beliefs support the purposes of the reforms. However, precisely the attention paid in the reforms to students' constructions of knowledge may lead to uncovering student misunderstandings that were previously invisible to teachers when they were using traditional practices. Others have found that teachers "discover" such potentially discouraging misperceptions when they probe students understanding (Russell & Corwin, 1993). Thus, one method of the reforms may serve only to highlight the apparent failures of the reformed methods, depending on how such information is interpreted. Of course, initial failure can be problematic for teachers, since teachers' success with the new approach is the most important source of information about personal efficacy (Marsh & Jordan-Marsh, 1986).

How can teachers tell if students have learned? On a more concrete note, it may be harder for teachers to know when a student has reached the reform's goals of understanding or being a good enough problem-solver than it was for teachers to know when students had learned their math facts through six. This may exacerbate an existing problem regarding the nature of teaching in general, and the difficulty of feeling efficacious as a teacher. As Denham and Michael (1981) note "In an educational setting, it is often not clear whether a teacher's experiences have been successes, failures, or a combination of successes and failures" (p. 44). Making a teacher's success harder to see may make the reforms even less attractive. In fact, a persistent issue regarding progressive reforms in education has been the lack of practical assessment tools that point to the efficacy of the proposed methods. Standardized achievement tests often do not provide support for a sense of efficacy for those who engage in non-traditional teaching practices. For teachers who are trying reform-oriented practices, what assessment results substantiate the effectiveness of the new approach?

With the broader and less certain student outcomes of the reforms, perhaps teachers may not simply need new grounds for feeling efficacious, as Smith (1996) suggested, they may need to feel efficacious in a different way.

A different sense of causing effects. There is a sense in which the teacher in reform-oriented practice might feel she can take less credit or less direct credit for student outcomes than could a teacher who subscribed to the traditional view of how teaching and learning took place. In this reform-oriented view of learning, the teacher doesn't teach the student directly, as a painter puts paint on a wall. Instead, the students' learning is always mediated by the students' attempts at sense making, and students may learn without any instruction from the teacher (Franke, Fennema, Carpenter, & Ansell, 1993). A teacher might not want to adopt the reforms simply because she doesn't want to accept the idea that she can't have a direct impact on students. To accept this idea might seem to threaten her sense of efficacy.

One area where teachers may need a new definition of efficacy involves classroom management. Newman, Rutter and Smith (1989) noted that orderly behavior by students is one of the most consistently influential dimensions for whether teachers can practice their craft with confidence. However, the reforms don't ask teachers to be "in control" of students in the traditional way, but seem to point to somehow getting students to be more self-regulated, and to have more authority. An illustration of this comes from the Cognitively Guided Instruction Program (CGI), one approach to mathematics teaching that might be classified as reform-oriented. Summarizing the views of teachers who had become more CGI-oriented, Franke, Fennema, Carpenter, and Ansell (1993) note: "The teachers indicated that the children created the learning environment. The children were the ones that determined the learning that occurred in the teachers' classrooms" (p. 36). Is the meaning of efficacy itself the same with such an approach?

Ball (1992) notes that, paradoxically, teachers are being asked to make their practice more uncertain at the same time that they are being asked to reliably produce more ambitious outcomes. A situation like the CGI example definitely seems more uncertain for teachers. However, positive teacher efficacy beliefs may make it more likely that teachers will allow students to have more say in their learning, as in the CGI example. Woolfolk and Hoy (1990) found that teachers with a positive sense of efficacy were more humanistic in their approach to classroom management and less likely to use harsh management strategies. Woolfolk, Rosoff, and Hoy (1990) reported similar findings, and that teachers high in efficacy were more likely to be "encouraging of student autonomy in problem-solving" (p. 143).

Finally, researchers have not paid much attention to individuals' motivation to maintain past accomplishments (Raynor & Brown, 1985). As noted earlier, teachers may balk at the reforms because they suggest that teachers' past accomplishments in terms of teaching procedural skills in mathematics were not as significant as teachers might have thought.

Can Teachers Still Cover the Content?

The reforms emphasize the deep exploration of important ideas in subject matter, which creates an apparent trade-off between depth and covering a lot of content. Russell and Corwin (1993) found that teachers attempting reform-oriented practice seemed to alternate between more and less implementation of the reforms, partly because "letting go" in the direction of more reformed teaching threatened them with not covering the content--a problem for certain efficacy beliefs.

Resistance from Parents and Others

One important contextual factor in the current reform efforts is how non-teachers view these new ideas about mathematics and teaching mathematics. One might expect parental and societal resistance to teaching a new form of mathematics, and less acceptance of the results that teachers get when teaching in reformed ways.

Wojciechowska (1987) noted how society acts to impede any radical effort at reform, saying that parents react negatively when the math taught to their children is different from the math they learned. Such a response sends negative messages to teachers about the effectiveness of their reform-oriented teaching.

In conclusion, there are many ways in which the reforms, and specific interpretations of them, might threaten teachers' feelings of efficacy regarding teaching mathematics. As someone researching her own attempts to teach in ways that are consistent with the reforms, Ball (1993) noted her uncertainties about whether the direction taken in a particular mathematics lesson was the most worthwhile thing to do. Coming from a well-known researcher of her own mathematics teaching, such a comment can provide reason for teachers to pause, and step back from attempting practices consistent with the reforms. If teachers experienced at teaching this way are left with such doubts, then do other teachers want to give up that familiar feeling of effectiveness in order to teach this way? Embracing the "wisdom of uncertainty" is not an easy path to choose.

Reform Support for Teachers' Efficacy Beliefs?

Despite all of the ways in which reformed teaching might threaten teachers' efficacy beliefs, teachers might also find their feelings of efficacy supported by the current reforms and by attempting reformed teaching. First, for many teachers, the reforms provide visible national-level support for some specific practices they favor (e.g., using manipulatives). Also, the reforms are broad enough (Cohen & Ball, 1990a) so that many teachers may be able to find aspects of the reforms with which they can experience success. Finally, attempting some of the reform-oriented practices may lead to obvious and tangible results, such as increased student engagement in hands-on mathematics activities.

The reforms might support efficacy beliefs because some of the recommended practices (e.g., extended discourse about students' understandings) allow teachers to learn more about what students know and are learning about mathematics. In one teacher's attempts to implement reform-oriented practices (Wood, Cobb, & Yackel, 1990), the teacher noted, as she began teaching math in this more constructivist way: "I never knew second graders knew so much about mathematics" (p. 502). Such discoveries about the extent of students' knowledge, could, depending on how they are interpreted, support teachers' efficacy beliefs.

Different Efficacy Beliefs?

Beyond the many ways in which attempting reform-oriented practices may raise, lower, or alter teachers' feelings of efficacy, the relationships between efficacy and outcomes may turn out to be different in this reform context than they have seemed to be in earlier research. Perhaps different types of efficacy beliefs will be required to teach in ways consistent with the reforms. Others have certainly suggested that motivation may actually be transformed by socio-historical change (e.g., Smyer & Crews, 1985).

Gaps in the Literature and My Research Focus

Despite all the research that has been conducted on teachers' efficacy beliefs, there is a great deal of work to be done. As Smith (1996) noted, "No currently published studies have linked teachers' sense of efficacy to changes in teaching practice in the context of reform" (p. 388). Hoping to understand relationships between teachers' efficacy beliefs and their attempts at reformed mathematics teaching, in the multiple contexts of their work, I initially organized this study around four questions. First, what is the nature of these teachers' efficacy beliefs regarding their mathematics teaching? Second, how are these teachers' efficacy beliefs related to their thinking about the mathematics reforms? Third, how are these teachers' efficacy beliefs related to their mathematics practice? Fourth, how can the above questions be understood in light of the multiple contexts in which these teachers carry on their work? These questions provided me with a focus for my research, although my questions changed somewhat as I learned from the teachers.

Research Methods

In this section, I discuss my views on efficacy beliefs and my rationale for using a case study approach. I then explain my data collection procedures, describe the teachers and schools involved, and explain how I analyzed the data I collected.

Theoretical View and Assumptions

First, I believe that teachers' efficacy beliefs are important. Bandura's theory (1986) has been central in much of the research into teachers' efficacy beliefs. It explains how such beliefs play a pivotal role in human agency. "Findings of different lines of research show that people who have a high sense of perceived self-efficacy in a given domain think, feel, and act differently from those who perceive themselves as inefficacious" (p. 731). People with a positive sense of efficacy tend to ascribe failure to lack of effort, heighten effort in the face of failure, and are more active processors of information than those with more negative efficacy beliefs (Bandura, 1989). In contrast, people who doubt their capabilities shy away from difficult tasks. They have lower aspirations and weak commitment to the goals that they choose to pursue. In taxing situations, they dwell on their personal deficiencies, the formidableness of the task, and the adverse consequences of failure (Bandura, 1989).

Significantly, efficacy beliefs are not a direct reflection of ability--people often have unrealistically high or low efficacy beliefs regarding a particular activity (Bandura, 1982). Even when skills are enhanced, there sometimes is no corresponding improvement in efficacy beliefs (see Bandura, 1989). In some studies, efficacy beliefs were a better predictor of future behavior than was past success and failure (Bandura, 1977). More specifically, teachers' efficacy beliefs have been related to a wide range of important outcomes in education. At a general level, efficacy beliefs may be important for teachers in the same way that they are believed to be important for people in general. "It is partly on the basis of judgments of personal efficacy that people choose what to do, how much effort to invest in activities and how long to persevere in the face of obstacles and failure experiences" (Bandura, 1989, p. 42).

Second, I believe that efficacy beliefs are reciprocally related to performance. Believing you can do something makes it more likely you will try, and success makes it more likely that you will believe that you can be successful in the future. However, causal attributions and one's own interpretations of a performance situation play crucial mediating roles in how past performance influences efficacy beliefs regarding the future.

Third, I agree with Bandura's explanation that there are four sources of information that influence self-efficacy beliefs (1976, 1982). These four sources are performance accomplishments, vicarious experiences (i.e., observing others' successes or failures), persuasion (e.g., "You can do it!"), and interpretation of one's own physiological states (e.g., "I'm nervous, maybe this is too hard for me"). Interpretation plays an important role in how each of these sources of information influences efficacy beliefs. I also believe that the process of reinterpretation may be a fifth source of information influencing efficacy beliefs.

Fourth, I assume that teachers' efficacy beliefs can vary greatly across context, type of students, type of teaching task, subject matter, and may vary by topic within a subject matter. Using hierarchical linear modeling to study efficacy beliefs, Raudenbush, Rowan, and Cheong (1992) found that forty-four percent of the total variation in teacher efficacy beliefs in their study was intrateacher variation. This confirmed their expectation and the belief of most efficacy beliefs researchers--that "perceived self-efficacy has a large contextually situated component" (p. 158).

Finally, I assume that there are a number of culturally influenced and developmentally influenced nuances of efficacy beliefs yet to be understood.

In Appendix A, I provide a more detailed discussion of efficacy beliefs in general, and teachers' efficacy beliefs in particular.

Rationale for Using Case Study Methods

My purpose is to try to understand efficacy beliefs in the context of mathematics reforms, with attention to relationships between beliefs and mathematics teaching practices. Smith (1996) suggested that understanding efficacy beliefs in the contexts of the current mathematics reforms will require: "a conception of efficacy beliefs that is nested in the interconnected web of social setting, teacher actions, perceived effects, and local educational values that make up teachers' work environment" (p. 400). With this conception of teachers' efficacy beliefs in mind, I chose to do case studies of three teachers, using "qualitative" research methods.

There are several reasons to use a qualitative, case study approach to study teachers' efficacy beliefs. Efficacy beliefs are the result of a psychological act of interpretation, and to understand them, we should gather individuals' interpretations, in words. Beliefs are constructed in particular contexts, and understanding teachers' comments regarding their mathematics teaching may require making our study and understanding of teachers more contextualized (Hoyles, 1992; Talbert & McLaughlin, 1993). Also, other recent advances in motivation theory have revolved around important qualitative differences in motivation (e.g., Ames & Ames, 1984a; Dweck & Leggett, 1988). Since there has been extremely little qualitative research into teachers' efficacy beliefs, such research may simply shed light on some of the qualitative dimensions of the issue. Sociological studies of education, and other studies of a more qualitative nature, while not always explicitly focused on teachers' efficacy beliefs, have generated many findings that are crucial for understanding efficacy beliefs (e.g., Lortie, 1975). Also, scholars using quantitative methods to research teacher efficacy beliefs have repeatedly noted the need for qualitative research in the field (Coladarci, 1992; Fuller et al., 1982). Finally, Smith (1996) makes explicit the need for qualitative case study research to understand relationships between teachers' efficacy beliefs and efforts to use reformed mathematics teaching practices:

> Because teaching is such a complex cognitive structure that is related to teachers' views of mathematics, teaching, and learning and the linkages they project onto teaching and learning, conceptual analyses should propose models that are well grounded in detailed case studies of individual teachers. (p. 400)

Putting together the relationships between beliefs, words, and meaningful actions, in context, is a major strength of the case study format (Stake, 1995; Yin, 1994).

Choosing the Cases

In order to understand the patterns of relationships between contextual factors and teachers' efficacy beliefs, I examined the cases of three teachers over four years, as they taught in three different schools in the Southdale School District in California. California was selected as a research site because "the state is at the leading edge of educational reform and is making an unprecedented effort to realize a new vision of mathematics teaching and learning" (Peterson, 1990b, p. 241).

California

The state is significant for its progress in developing its math reform efforts, and for the resources within its borders. The California Department of Education has published several mathematics reform documents mentioned earlier, and implemented an alternative state-wide assessment program called the California Learning Assessment System (CLAS). The new CLAS assessment is seen as more consistent with reform-oriented goals for math teaching. Resources such as AIMS, EQUALS, Math Their Way, Marilyn Burns, and many other interesting math programs and math educators are based in California. During the study, the state's ability to vigorously pursue these reforms was hampered by their ongoing economic woes.

The District

The Southdale School District was initially chosen for research within the larger EPPS research project because it was a large urban district involved in significant efforts aimed at teaching mathematics for understanding. Schools were chosen to provide some diversity of settings within the districts being studied (Peterson, 1990b).

The Teachers

I focused on three teachers in order to allow for interesting cross-case comparisons to emerge while still being able to do reasonably in-depth analysis of individual teachers' efficacy beliefs and practice. I chose these three teachers from among ten teachers I had observed and interviewed during my participation in the EPPS project. I chose these teachers in part because the ambitious reform efforts in California made that an interesting policy context, and because my impressions from research already completed indicated that their cases allowed for interesting comparisons.

The three teachers were initially selected for the ongoing Educational Policy and Practice Study in two ways (Peterson, 1990b). Peggy Turner (all names are pseudonyms) and Phoebe Notion were among the second- and fifth-grade teachers initially selected for the EPPS project, which began in the 1988-1989 school year. Second and fifth grades had been chosen in order to see how policy efforts were playing out in the primary and upper elementary grades. Molly McCarthy was chosen for this study because she was identified as an expert math teacher and because she taught in the classroom next to Peggy Turner, and seemed to be influencing her practice.

The three teachers provide contrasts in terms of type of school, type and ability of students, their own knowledge of and commitment to the mathematics education reforms, their mathematics teaching practice, and their feelings of effectiveness in teaching mathematics. The variations across these teachers provided an opportunity to learn about, and share three useful and interesting stories.

The School District

Southdale was a major metropolitan school district with a school-age enrollment of around 125,000. The ethnic composition was 35% White, 29% Hispanic, 16% Black, and the remaining 20% were Asian, Pacific Islander, or American Indian. Forty-five percent of the students were eligible for free or reduced lunch, and 40% received Chapter I services. The district had been characterized during the time of this study by an emphasis on subject matter reforms, teacher empowerment, school-based management, and by budget crises. Financial cutbacks had substantially reduced the central office's ability to either monitor or support schools and teachers. Despite some indications of a serious reform orientation at the district level, Peggy reported comments from a district math coordinator that seemed to suggest some mixed feelings at the district level about the math reforms.

Timberside School. The school was in an upper-middle-class section of the city, and had roughly 800 students. The ethnic composition was 62% White, 15% Hispanic, 13% Indo-Asian, 6% Black, and 4% "Other." Fourteen percent of the families qualified for Aid to Families with Dependent Children (AFDC). The district's emphasis and the emphasis of the principal at Timberside on de-centralized control and teacher empowerment had created a climate in which the principal had allowed teachers to order materials that she saw as somewhat contrary to the spirit of the subject matter reforms. Debbie Jones, the principal at the school for the first three years of the study, was a proponent of teaching for understanding in mathematics. More than 70% of the school's 5th grade students had scored above the 50th percentile on the Abbreviated Stanford Achievement Test (ASAT). The school had substantial resources and parent involvement. Molly taught at Timberside School during the entire four years of the study, while Peggy taught there during the first three years of the study.

Columbus School. Among the poorest and most ethnically diverse schools in the city, the 1300 students spoke 23 languages, and 96% qualified for free or reduced lunch. The ethnic composition was 45% Hispanic, 25% Indo-Asian, 18% African-American, and 12% Caucasian. The principal was a proponent of using manipulatives in mathematics, and had encouraged teachers to adopt a manipulative-based mathematics series. Three different mathematics programs were used in the upper grades at Columbus during the four years of the study. The school also had substantial resources, but minimal parental involvement. Phoebe taught at Columbus during the entire study, while Peggy had taught there prior to moving to Timberside, and before this study began.

El Dorado School. The school is in a middle-class section of the city, and had roughly 700 students. Although designed as a magnet school, the school predominantly served students from the neighborhood. This high-profile magnet school for the arts had received national attention for its programs, including a visit from President Clinton. Impressive artwork dominated the courtyards and walkways of this school, and there was a great deal of financial support available at the school for arts supplies and specialized arts instruction or activities. Judging from Peggy's comments, it sounded as if mathematics was not a focus at the school and conceptions of teaching mathematics were quite traditional. Peggy taught at El Dorado during the final year of the study.

Data Collection

Qualitative case study research generally relies on three types of data--observations, interviews, and artifacts (Bogdan & Biklen, 1992). I used each of these types of data, and collected during three time periods: prior to developing my research focus, during the period my focus was emerging, and after my focus was established. Of course, the process was a bit more complicated than that. My research focus partly grew out of what I had learned about these teachers in the first two years of observing and interviewing them. Even after my focus was established, it continued to evolve, consistent with the responsive nature that this form of research usually takes (Hammersley & Atkinson, 1983).

My research began in the fall of 1991 with Peggy and Phoebe and in the spring of 1992 for Molly. It continued through the spring of 1995 for all three teachers. Below, I explain more about the details of my data collection and analysis.

Observations

On each visit to the teachers, I observed at least half of the classroom day. Observations were planned in order to see instruction in mathematics, reading, and language arts. Observations were sometimes planned to observe instruction in a topic that the teacher had identified as one of her strengths (e.g., social studies for Phoebe Notion).

During the observations, I took field notes, documented classroom layout and materials, teaching strategies, materials and language used, and students' actions and language during interactions with the teacher and with each other. During the first three years of the study, an observation analysis form used in the EPPS project provided a framework for focusing observations. Interactions and instruction deemed important were audiotaped, which included the vast majority of every observation. Over time, observations increasingly focused on the three teachers' mathematics teaching practices. My own reflection and on-going discussions with others in the EPPS project provided greater focus to my observations over time. I observed Molly on six days, Phoebe on five days, and Peggy on eight days.

Interviews

Teachers were interviewed once or twice during each day they were observed. An interview protocol developed within the EPPS project provided the main focus for my interviews for the first three years of this study. Interviews were semi-structured in nature, beginning with questions from the EPPS interview form. Follow-up questions were asked to help better understand the teachers' answers and to piece together an overall picture of each teacher's experience and thinking. My reflection and discussion of these cases with colleagues on the EPPS project informed these follow-up questions as the study progressed. For each interview, I also prepared additional questions that went beyond the standard EPPS interview. Given my interest in motivation, I wove in a number of questions that focused more directly on the teacher's motivation and their view of student motivation. During the last two interviews with each teacher, I focused more explicitly on efficacy beliefs in relationship to that teacher's practice and thinking about the mathematics reforms. Questions focused on teachers' goals, their perceived effectiveness when using particular teaching practices, their observations of student engagement and learning, their thinking about the effectiveness of reform methods in general, and the learning experiences and material and social support they had to teach in more reformed ways. I also hoped to make some connection between quantitative and qualitative approaches to researching efficacy beliefs, to better understand how some teachers answer traditional Likert-scale questions. Thus, I asked each teacher the two questions from the Rand studies about teachers' efficacy beliefs. The first Rand item is "When it comes right down to it, a teacher can't really can't do much, because most of a student's motivation and performance depends on his or her home environment." The second Rand item is "If I try really hard, I can get through to even the most difficult or unmotivated students." I asked the teachers to focus on mathematics when answering the second Rand item, which is a question about personal teaching efficacy beliefs.

In addition to shorter interviews that took place during recess or lunch, I conducted six interviews with Molly, and seven each with Phoebe and Peggy. Ranging from one hour to two-and-a-half hours in length, and averaging an hour and forty-five minutes, transcriptions of interviews ranged from 50-100 pages, yielding hundreds of pages of interview data for each teacher.

I also conducted several 30-60 minute interviews with the principals and vice principals at Timberside, and with a vice-principal at Columbus. Other researchers from the EPPS project conducted similar interviews over the years with the principal at Columbus school. These interviews provided additional information about the schools, and about the activity and emphases within the school with regard to mathematics teaching. All interviews were audiotaped and transcribed.

Artifacts

Although artifacts were not a central source of data for this study, I collected worksheets used in the classes, documents that provided information on schools and the district, and documents from the reform efforts, such as the NCTM Standards, and the 1992 California Mathematics Framework. I took many notes and dictated comments on the materials and the physical environment of each classroom.

Overall, this approach to data collection provided some data that was comparable across teachers and some data that was individualized for individual teachers and schools. For example, all teachers were asked about their efficacy beliefs regarding teaching math, but different reform-oriented practices were given somewhat more emphasis in questions to different teachers. For example, the Math in Stride mathematics text was a major part of the story in Phoebe Notion's case, but was not being used by Molly McCarthy, and thus, was not a focus of interviews.

My Role in the Classroom and with the Teachers

As an observer, I tried to be unobtrusive, but friendly. I was introduced to the students each time I visited. Students were sometimes curious about what I was doing, but sometimes did not seem to notice me. I responded to students' questions about my tape recorder and what I was doing, but asked them few questions.

On two occasions, Peggy and Molly asked me to watch the class for awhile. I did not lead any activities or engage in any substantial interactions with students regarding their work.

I felt I had a good relationship with each of the teachers. All three confided in me various feelings they had about what was going on at the school. I felt each teacher responded openly and honestly to my questions, but I believe that Peggy was more conscious than were the others about putting herself in a good light in my eyes. Phoebe and Peggy both talked at great length in the interviews. Molly was always willing to talk about her students and mathematics teaching, but seemed more business-like, and didn't like to waste time.

Data Analysis

Data analysis and collection were interactive in the ways described earlier, with preliminary analysis of data helping to shape subsequent data collection. The goal of my data analysis was to create a case study for each teacher, and a cross-case analysis. The data analysis consisted of three main phases. From the fall of 1991 through the spring of

1995, I worked alone in collecting and reflecting on data, and collaboratively worked with colleagues on the EPPS project to understand these cases and broader conceptual issues regarding the reforms, teacher learning, and mathematics teaching. From the summer of 1995 through the fall of 1996, I worked alone to analyze and categorize data. During this time I created rough drafts of the teacher cases. From December of 1996 through the spring of 1997, my analysis and writing continued in the context of substantial collaboration with Penelope Peterson, which included weekly hour-long phone conversations and exchange of memos and drafts of the cases.

Analysis of Observations

Following each observation, a field report was prepared, based on the form used within the EPPS project. This field report provided both descriptive data on events observed, and analysis and interpretation of the activities observed as they related to reform-oriented teaching practices.

These field reports provided a basis for constructing examples of each teacher's mathematics teaching. For each teacher, the activities and interactions chosen were selected for two reasons. First, I believed they were characteristic of her mathematics teaching. Second, they highlighted important issues regarding that teacher's efficacy beliefs in relationship to her use of specific mathematics teaching practices.

Analysis of Interviews

Through careful reading of interviews, I identified segments pertaining to major issues such as teaching goals, efficacy beliefs, and reform-oriented teaching methods. Most of the major analytic categories were chosen in advance, but others, such as teachers' beliefs about student motivation, emerged during writing and analysis. Documents reflecting particular issues were read, sorted, and re-read, in order to identify salient themes and crucial data that was to be included in each case.

The process I followed is similar to some of the processes of analysis and interpretation that Wolcott (1994) describes, such as the search for patterned regularities in the data. For me, the most important elements of the process were time-consuming immersion in the data, a great deal of reflection, repetition, and "working with" the interview data, and the ideas and feedback that came out of ongoing discussions with Penelope Peterson.

Analysis of Artifacts

Although not a main data source, review of artifacts collected, including handouts and reform documents, was also important to case construction. These were used to add detail to teaching examples from observations and inspired a number of follow-up questions during interviews.

Analytic Memos and Drafts

I received some feedback early in the process from colleagues on the EPPS project regarding analytic memos I had written about these three teachers. The main feedback I received came from Penelope Peterson regarding the analytic memos and drafts I had written for the teacher cases and cross-case analysis. I also wrote reflective memos to myself regarding issues that emerged during analysis, procedures for analysis and the construction of the cases. The value and uses of such analytic memos has been discussed elsewhere (e.g., Miles & Huberman, 1994).

Chapter Two

THE CASE OF MOLLY MCCARTHY

Introduction to the Cases

This chapter presents the first of the case studies of the three teachers from the Southdale District, whose stories I studied from the 1991-1992 school year through the 1994-1995 school year. Each case study consists of four main parts. First, I provide examples of the teacher's mathematics teaching, and discuss each example in light of the teacher's beliefs about students' motivation and learning. Second, I discuss the main themes in each teacher's beliefs about motivation and learning. Third, I examine each teacher's efficacy beliefs in relationship to her attempts to teach mathematics in reform-oriented ways. Finally, I examine how social factors and each teacher's own efforts influenced the way her story turned out. The fifth chapter of this study compares and contrasts the teachers, discussing lessons to be learned from looking across the cases.

Molly McCarthy, Who Loved Teaching Mathematics This Way

Watching Molly McCarthy's Mathematics Teaching

As I arrived at Molly's third-grade class one day, her students were using the district and reading texts as hand weights for their morning exercises. Molly gave me two of her new books for teaching mathematics, with a note saying she had tried one of them, and thought I'd be interested in them. This was a familiar feeling--Molly was excitedly sharing with me new ideas for teaching mathematics. Molly was unusual in that she rarely used the district mathematics text, except in these exercises, and said "I could teach math all day." When a teacher doesn't use the textbook, and is excited about teaching mathematics, one wonders--what does her teaching practice look like? I turn next to examples of Molly's mathematics teaching, to illustrate her practice, and examine some of the reasons why she taught the way she did.

How Many Budgies Should You Buy?

Molly began mathematics one day by asking students to recall when a student brought a parakeet to class. They established that the nickname for a parakeet is a "budgie," and to a few excited "Yea's," she announced "The Budgie Problem." She said they'd depart from their usual method of solving problems together. As this was near the end of the year and they were getting to be better problem-solvers, not only was she going to ask them to work alone (which drew a few more excited whispers), but she was also going to make the problem harder. Molly continued: "and then, [rise in voice], when we're through with this, [dramatic pause] we're going to do some math, the last Math Quest lesson." Many students excitedly cheered this news, and started talking animatedly. Then Molly passed out "The Budgie Problem":

> A bird collector wants to buy as many budgies as he can for $50. Blue budgies cost $10 each, green budgies cost $3 each, and yellow ones cost $0.50. He wants at least one of every color. How many budgies should he buy?

Molly changed the problem so that the collector wanted at least <u>three</u> budgies of each color, then reviewed what they knew about the problem. Molly said the collector wanted to buy as many as he could for fifty dollars, and asked if he would then get only three of each color. Students gave the signal baseball umpires use to signal a runner safe, which meant "no" or disagreement. Before starting, she told them to write down "a little bit telling me about how you came to your conclusion, like we usually do." She told them to include some numbers and writing, and "whatever else you need to have," and to "think about the strategies we have used in problem solving."

As students started work, Molly showed me a student's math portfolio, and was very interested in the student's work. Then she circulated, looked intently at what students were doing, and gave each one a problem-solving strategy inventory:

PROBLEM-SOLVING STRATEGY INVENTORY

Think about your use of strategies when solving the problem and check the following that apply.

1. ____ I didn't think about using strategies at all.
2. ____ The idea of using strategies came to mind, but I didn't think about it much more.
3. ____ I looked at a strategy list, but didn't try a strategy.
4. ____ I looked at a strategy list and picked a strategy, which I tried.
5. ____ I didn't look at a list, but just thought of a strategy to try.
6. ____ I used at least one strategy and it helped me find a solution.
7. I tried the following strategies:

____ guess and check	___ solve a simpler problem
____ make a table	___ work backward
____ look for a pattern	___ draw a picture
____ make an organized list	___ write an equation
____ other ____	

Molly then told me enthusiastically about the new 4th-grade CLAS test. Later, she urged students to finish up, and they discussed the strategies students had used. Many made an organized list or table, or used "guess-and-check." Molly said they would look quickly at how one girl did the problem, and then go on to Math Quest. She turned on the overhead, and wrote the girl's solution, reading aloud as she wrote:

Blue	10 + 10 + 10 = 30	
Green	3 + 3 + 3 + 3 = 12	
Yellow	.50 + .50 + .50= 1.50	
	10 birds	$43.50

She asked the class if that one was "easy for me to read," and what the question was (i.e., How many budgies should he buy?). Molly continued:

> So, she might have been able to get a little bit closer, because this one what? Came to what? [Molly added it up out loud with the class.] [Jessica] could have gotten a little bit closer but that one was very good--well done. It was really easy for me to see, though, cause Jessica--it's beautiful, she could have gone, if she probably had more time, she could have gone on and said, "Well now, let's see, maybe I could have had another $3 here."

Then Molly asked the class "Would she have been able to get another $3?" They said "yes," and Molly continued: "and maybe another 50 cent bird?" This seemed to be a rhetorical question. Molly said "She could have worked on it a little bit more, but I think you ran out of time. But it was very easily done, very easy for me, to see like this."

Then, looking at what others did, Molly said, "Oh, these are, these are wonderful. OK." She didn't lose anyone's attention as she moved to the next problem: "What we're going to do today is a fun strategy that people don't use very often, but it's a lot of fun, it's called, ready?--[Dramatic pause]--Act it Out!" Students cheered this, and were excited as Molly passed out an "Act It Out" handout, a transparency of which she also showed on the overhead. Act it out was the last of the problem-solving strategies she taught each year, and to introduce it, the class did a problem in which eight retired butlers each shook the hand of each other butler once at a meeting of their club of retired butlers. Students were to figure out how many handshakes there were in all. After eight students modeled the act it out procedure for this problem, they did two similar problems in table groups (the room was arranged in four-desk clusters). After each problem, one or two groups explained to the class how they solved that problem, and what answer they got.

Molly quickly moved the class on to Math Quest problems, but a few questions remain for us. In exploring Jessica's solution to the budgie problem, Molly suggested two additional birds, for a total of 12, but you really could get 28 birds total. Other students' solutions had more birds, including 28, but Molly didn't correct or modify Jessica's answer any more, nor provide the correct answer. She did not explore with students what strategy might have been most sensible for solving the problem nor did she discuss the logic of getting only three blue birds and three green birds. Why did she move on without providing corrections, and trying to get more learning out of this activity? Molly acknowledged in the interview on this day that she knew some of students were still struggling with this problem, and she thought this was a good problem, but she had to cut it off. Why?

One possible reason for cutting off a good problem may have been that she tried to balance students' motivation and learning. To understand how she did this, we first have to know her goals for students in both areas, and her beliefs about student motivation and learning.

In this section, and throughout the cases, "motivation" is broadly construed, and encompasses a variety of teacher beliefs and actions with respect to students' liking of mathematics and engagement with it.

Molly's beliefs about motivation. One of Molly's goals for mathematics was motivational: that students "would like math, have a good attitude about it, and want to go on and pursue it more." How did she believe she could teach mathematics to support such motivation? One way to support students' motivation was to keep the lesson moving at a brisk pace, to not let interest lag. Thus, she said about the budgie problem "I really had to cut it off because some of the kids got it quite quickly and others just were struggling." She said "I really like to see them struggle with it a little bit," but keeping the pace moving at this moment may have struck the right balance of motivation and learning for the greatest number of students. She made sure not to bore those students who already had it, but she left other students with a mental object of interest--a puzzle to wonder about.

Also related to motivation, the problem connected mathematics to students' lives (i.e., their parakeet experience) and Molly believed such connections made mathematics more meaningful and interesting to them.

Importantly, Molly's practice was informed by her belief that children naturally found puzzles like the budgie problem interesting and fun: "Kids like games, they like to puzzle through things, it's just sort of part of their nature, and that's why I teach the way I do." While the vast majority of Molly's students were identified as "gifted," she believed children's enjoyment of games was universal. Similarly, while Molly said she hadn't been a particularly good math student, and still got puzzled about some things in math, she liked it because it was "puzzle-like," and "it's fun, it's a game." It certainly seemed fun for students on this day, as they had the excitement and engagement many teachers might consider impossible in mathematics.

Molly's beliefs about learning. Molly's second main goal for students in mathematics involved learning: "I would hope that they would have meaning to math. That they would understand what they were doing--probably that place value was really strong in their minds, and good number sense."

For Molly, heading in the right direction in mathematics meant learning the things in the NCTM Standards. One day, she read to me an overhead she used with parents to share with them her vision of mathematics curriculum. She connected this vision to that day's activities: "Mathematics is problem solving, mathematics is communication--they certainly were doing that. Mathematics is reasoning, connections, estimation, number sense and numeration, geometry and spatial sense, patterns and rank relationships. I hit them all."

What were Molly's beliefs about student learning, and how did she think she could teach mathematics to support such learning?

First, in getting away from textbook lessons, and giving students meaningful problems to struggle with, Molly engaged them in the non-traditional experiences that she believed built useful skills, and actually expanded their intelligence:

> Not just in math, but that kids' intelligence can actually be improved, you know, by doing the kinds of problem-solving approach to reading or math or social studies, rather than just filling in the blanks. Their thinking can actually improve if they do things on a problem-solving basis.

A handout for parents emphasized that "intelligence is a function of experience," and explained how enriched experiences "associated with enthusiasm" by the learner result in brain growth and greater intelligence. However, the handout warned that traditional teaching bore no such fruit: "Dittos do not make dendrites!"

Getting away from traditional practice partly meant students' learned to use a set of problem-solving strategies, as they did here. Learning these strategies related to an important goal of hers: "I like 'em to be able to think creatively and try to solve it in more than one way." Most of her students hadn't been taught problem-solving strategies by other teachers, "so it's all pretty new to them." She gave students a problem to solve at the beginning of the year, but told them they couldn't solve it the traditional way. Many students replied "well I can't." Molly recalled one girl who got very upset and insisted there was no other way to solve the problem. Molly was clearly trying to undo a student belief that she saw as an obstacle for them: "If they forget the rule, something comes along and blocks them, there's absolutely no way to solve the problem. They can't--they don't know how to attack it from any other direction." It was as if Molly was treating a learning disability created in students by the traditional teaching of other teachers.

By helping students learn many ways to solve problems, Molly was building students' mathematical efficacy, or power. Armed with an array of problem-solving strategies, she believed they were less likely to be stumped by future problems. Students' motivation might be undermined if they became frustrated by problems they didn't know how to attack.

Molly emphasized being able to explain their reasons and problem-solving. Thus, during an act-it-out problem, three girls wrote their answer on the overhead and explained how they got it. Molly chose these girls to present because they wrote both the answer, and also how they did the problem. For Molly, explaining something aided understanding: "When they make themselves clear [while communicating] they're clearer in their own minds." Not surprisingly, she was working on using a rubric for scoring mathematical problem solving, in which the explanation and reasons given were key criteria.

Molly was not teaching just the basics. She wanted students to struggle and learn, to expand their intelligence by enthusiastically engaging in meaningful mathematics problems. There are many questions left about how she tried to create such an ambitious teaching practice. Turning to other examples of her teaching, we will focus on better understanding what her teaching was like, what her beliefs were about students' motivation and learning, and how her beliefs and practices were related.

Building Understanding with Base Ten Blocks

I twice observed Molly teach about decimals by using sets of base ten blocks, and base ten blocks also shown on the overhead. One day, she began with a "flat" on the overhead, and talked about what it would look like under magnifying glass. Asking students to close their eyes, she put up an overhead of a flat with all 100 squares visible. She placed a "long" and a single unit on the overhead, representing one tenth and one hundredth respectively. She established common language for these pieces, noted that there were 100 squares on the flat, then showed one of the squares colored in: "So how many have I colored in?" A student came to the overhead, wrote 1., and several students gave the umpire's safe sign--signaling that they disagreed. Another student wrote .1 on the overhead. Students again signaled "safe:"

Molly:	OK boys and girls, we're going to have to come to an agreement, because this [indicating the orange flat under the overhead "magnifying glass"] Could we call this "1"? What could this one be? [indicating the one tenth "long"]
Student:	One tenth
Molly:	Is that OK?

No one signaled "safe," and Molly said "OK, let's call that one tenth," and repeated exactly this process for one one-hundredth. As she cleaned off the overhead, one child from each table cluster quickly and quietly got base ten blocks for their table. Having passed out place value sheets, she asked students to put a one on their board, then one tenth, then another one tenth, then asked a student what they had:

Student:	One and two tenths.
Molly:	Very good, you said it just like I [want you to]. What does the "and" stand for?
Student:	[inaudible]
Molly:	Right, the decimal place.

Working quickly, they got to one and five tenths, Molly asked a girl to say what they had, and she answered "one and a half." Molly agreed that this was correct but said she wanted her to use a little different vocabulary. The girl said one and five tenths, Molly agreed, and they went on. They repeated the same process of naming the one-hundredths, starting with one one-hundredth, and doing a few more numbers as they worked up to ten one hundredths.

After a quick stretch break, she asked pairs to work together to represent .2 with the blocks in any way they could. Walking around, Molly saw a pair who had used two longs, and asked them if there was another way of showing .2 that wasn't two tenths. Students were very engaged in discussing this, as here again there was a connection between the symbols and the models they were making. Then she asked them to show .2 using the fewest pieces possible. Most pairs used two longs, but there was more animated discussion. Then she asked pairs to put out thirty seven one- hundredths pieces, and asked if there was a way they could do this without counting them all (each person in a pair had twenty units). After this, she asked students to do an exchange to arrive at the fewest number of pieces to represent thirty-seven one hundredths, and talked through the exchanging process with them until they got down to ten pieces. A student wrote this as .73 on the overhead, and a few students signaled "safe." Molly noted "OK, we have some disagreement," and the boy immediately went back up and wrote .37 on the overhead.

Molly: How would we read that?
Student: Zero, three tenths and seven one hundredths.
Molly: OK, but is there some way to say that. I want [you] to say, to say it as one word.
Student: One and thirty-seven one-hundredths.

Molly indicated that this was correct, and they cleaned up and segued immediately into reading "The Velveteen Rabbit."

Molly's beliefs about motivation. How does this example reflect Molly's beliefs about student motivation? First, there was variety, with students alternating between creating concrete models of the decimals, looking at what was modeled on the overhead, saying the name for a decimal, and looking back up to the overhead to see how a decimal was written in numerals. Molly believed variety was crucial for keeping math interesting, since she saw her own children "get bored with math, get turned off" and she realized "that kids just need to have something interesting."

She also used the overhead here, which she believed was an important tool for keeping students engaged. In fact, the overhead would be the first tool she would want if she was teaching math on a deserted island: "Well I don't know what I'd do without the overhead, because you keep kids' interest with that." Indeed, even while learning basic mathematical conventions, students were interested.

Molly's beliefs about learning. Molly thought using manipulatives was crucial for building understanding. Indeed, Molly had a three-stage theory of student learning. In level one, students built concepts by using manipulatives. In level two, students connected the concepts they had constructed to abstract representations (numbers, words, symbols). At the third level, they operated entirely using the abstract representations of mathematical concepts. She believed this was a universal learning sequence for all students, although with less able students, one would need more time at level one to build concepts. Consistent with this, she had students get manipulatives in their hands, established a name for each size of the blocks, then they built representations of numbers, then learned how to write and say what they had built. If students skipped the concrete "doing" step in this sequence, they might wind up with some rote skills not built on a solid foundation of conceptual understanding: "They have to do it before they get it." While doing was a foundation for Molly, writing and talking about mathematics were crucial for understanding and for learning to communicate mathematical ideas.

As was common, students worked together in table groups, and she believed such peer-peer learning was very important--"You know, that's where most of the teaching comes in on games like that--partners help 'em." When students went to the overhead to give answers or explanations, Molly often merely echoed for the class what students had said.

Finally, it was interesting how Molly gave students time to experiment with different ways to represent a decimal. Even when a student wrote a decimal incorrectly on the overhead, other students signaled it was incorrect and the student figured out how to write it correctly. With her concerns for pacing, when teaching <u>conventions</u> of mathematics, why did she have students experiment with different ways to model decimals, and give a student time to correct his error on his own? Showing or telling them would have been faster, so why didn't she do that? In upcoming examples, we'll explore further why Molly, with her concerns for pacing, didn't just model or tell answers.

<u>Sunrise, Sunset</u>

One day, Molly began mathematics by asking students to predict the times of sunrise and sunset for the previous day. For several weeks, they had been charting these times each Thursday, and comparing them with those of previous weeks. Students groaned as she asked them to get out these charts, but she encouraged them to do it, and looking at the past pattern of sunrise times, students were soon engrossed in guessing the time of that Thursday's sunrise. One student predicted 5:41 am, and Molly asked him why:

> Student: Because last time you take away three, so I just did the same thing.
> Molly: So you're just doing the same thing over again? Remember, we had the difference of seven, and then seven, and then six, and five, and then three, do you think three would be a pretty good estimate? A difference of three?
> Student: Yes.

Other students predicted 5:41, 5:42, and 5:38, and Molly asked each how much of a difference the predicted time was from that of the previous week. Then she looked up the time in the paper, and wrote 5:41 on the overhead, and several students excitedly exclaimed "Yes-s-s-s." Agreeing it was a difference of three minutes from the previous week, they then worked on predicting the time of sunset. Most students predicted 7:53, which represented a difference of five minutes from the previous week, and gave the explanation that the time had changed by five minutes in each previous week. One boy chose 7:52, only four minutes later than the previous week and a smaller change than in the past. Cheers came from a minority of the class as Molly wrote 7:52 on the overhead as the time of sunset. Students who got it wrong seemed disappointed, but they went right on to calculating the number of hours of sunshine and darkness. This included one student error, with Molly providing her usual indirect hinting to the boy who had it wrong, rather than correcting him directly.

Molly's beliefs about motivation. Consistent with Molly's beliefs about motivation, the content here was connected to an object or theme students had experienced. Though a different connection than that of the parakeet or the base ten blocks, the sun is real to us, interesting, and affects us daily. Moreover, Molly told me they were studying astronomy in the science lab, and she was carrying that topic into mathematics. Thus, she was also making meaningful connections across subject matters.

A curious note regarding motivation was the initial groaning by students. This was the only sign of disinterest I observed during any math activity. Molly encouraged students to try it, and energetically moved on, and soon they were involved in guessing the patterns. How did she get the students' interest back? I'll try to better answer this later on.

Molly's beliefs about learning. In this activity, students were involved in looking for patterns, something Molly believed was crucial for learning mathematics. Perhaps most interesting regarding her beliefs about learning was how Molly allowed students to look for and figure out mathematical patterns largely on their own. Just as she didn't correct the budgie example, nor tell them the best problem-solving strategies to use, here she never pointed out how the 5:38 prediction didn't fit with the pattern, and never even explicitly stated what the trend was. Most students seemed to have something of a feel for the trend, but not all did, and she could have explained it explicitly, but didn't. As with the budgie example, she didn't squeeze as much learning out of this as she could have. Perhaps she didn't give more assistance because of her belief "that kids learn themselves."

We'll look for more answers in the next activity, including whether Molly's students learn entirely by themselves.

That Amazing Old Sun

Later the same day, the sun theme continued, with students hanging on every word as Molly read a story about the sun from the current Ranger Rick. Opening lines about the sun steaming up the air in autumn after an early morning shower, and warming a patch of carpet in winter through the window gave way to discussion of facts about the sun. After discussing and writing down the percentages of various elements in the sun, and noting how a whole is made up of one hundred percent, they pushed on. Here, Molly again connected mathematics to students' experiences with the sun, and as she went, interwove the mathematical conventions of writing numbers into this interesting story. Information about how the sun doesn't burn like wood does, or it would burn up, was followed by a reassurance that the sun wouldn't burn up for "five billion more years!" After asking the class to write the digits that make five billion, Molly called on a girl to write that on the overhead. When the girl wrote 5,000,000, Molly said:

Molly:	OK, now let's stop and think. If we go over one two, three, we call this one what?
Girl:	[Inaudible. Another student said "Oh yeah" as if realizing something.]
Molly:	Everybody, what's this one? One, two, three, [counting over the zeroes] wait, stop, what's this one? One, two, three, [counting the zeroes again] what do we call this one?
Students:	Thousand.
Molly:	This would be thousand, and then one, two, three, this would be?
Students:	Million. [The girl at the overhead then immediately wrote in three more zeroes on the overhead.]
Molly:	So she's saying "Whoop." Now we've got, say it with me ...
All:	Thousand, million, billion.
Molly:	Right, how many zeroes are there?
Students:	Nine.
Molly:	Nine, wow, OK.

Then Molly asked them to write four-and-a-half billion in digits, to note the age of the sun. The boy who wrote this on the overhead got it right (4,500,000,000), but many students had written "4 1/2 billion," and she told them "Half a billion is five hundred million, isn't it?"

Molly read on, skipping parts of the story "so I get to the math part." This also kept up her brisk pace. Students seemed impressed that the sun was twenty seven million degrees Fahrenheit in the middle, but as Molly looked at how they had written this, she said "twenty seven million degrees Fahrenheit, twenty seven million degrees Fahrenheit." Although several students called out "I got it," she replied "So far, I haven't seen it yet." Molly called on girl to write the answer, to the disappointed groans of those not chosen. Although the girl was just about to write it on the overhead, several students asked Molly eagerly, "Is this it? Is this it?" Molly deferred to Amy, the girl at the overhead: "You look and see, she's gonna' do it." Amy wrote it up on the overhead, complete with a degree sign and the "F" symbol. Molly noted that the degrees sign and F had been what was missing from others' papers.

Then they wrote the sun's temperature in degrees centigrade, then pushed on to the diameter of the sun--865,000 miles across. After a boy wrote 865,000 on the overhead, Molly indicated it wasn't quite right, hinting at, but not giving away the answer: "eight hundred and sixty-five thousand, oh, it's not quite complete, eight hundred and sixty-five thousand..." As she paused, the boy wrote "miles" after the number. "All right, there we go boys and girls," Molly said, and read on. She asked them to visualize the head of a pin, and read from the story: "If the sun were the size of a basketball, the earth would be the size of a pinhead." "Whoa!" students exclaimed, seemingly very impressed. She repeated this point, then noted that the sun is ninety-three million miles away. She read that if they could drive to the sun at sixty miles an hour (about the speed their parents drive, she said) and they drove all day, every day, "it would take you, [dramatic pause] one hundred and seventy seven years of nonstop driving." From the students, "Whoa's" and "Wows" erupted again in amazement at this fact. She repeated it and they agreed that this was a very long way away.

Molly's beliefs about motivation. Molly treated the mathematics as interesting, even dramatic, and like a storyteller, treated it as dramatic with her use of dramatic pauses before introducing some of the mathematical facts about the sun. Of course, the punch lines in the stories she told today, which students awaited with great interest--were mathematical. In reflecting on how she regained the students' interest in doing the sunrise-sunset chart earlier, I believe the answer lay partly in the degree to which she engaged them in working on an unsolved puzzle. She let the tension build about what the correct answer really was, then after dramatic pauses, revealed the answer to great emotional response from the students. Here, with the sun story, the drama was largely played out orally, although how you wrote those big numbers created some suspense. With the sunrise-sunset chart, the mathematical drama was played out on the stage of the overhead, for all to see. More interactive than a play or movie at the theater, the mathematical dramas unfolding in Molly's class were engaging and enjoyable for all. This helps explain why Molly wished the school day was longer, and why she "could teach math all day." As she pointed out: "I enjoy teaching the way I teach, 'cause the kids are happy. In fact, they like it. I've never had discipline problems--they're always interested."

Here, Molly had students write the numbers as she said them. A student then wrote the answer on the overhead. After each student had written it the right way, she went on. This practice reflected detailed beliefs about how to keep students engaged. That is, she could have just read the story, and written down the numbers herself, "But you keep the interest more if they have to write it down, and then they look up."

Molly's beliefs about learning. Molly emphasized mathematical terms and symbols here, but again taught them in the context of a meaningful situation. She believed people can learn things in a way "that didn't mean anything to them," but will soon forget it: "two weeks later, I just can't remember it--and that's the way they [students] are, unless there's some meaning to it."

Even with a simple convention of mathematics--how to write a number in digits--Molly treated it as something to wonder about and discover. Even when students erred, she didn't correct them or give them the answer, but helped indirectly, giving hints, so they could still discover the answer partly on their own. She did this for the girl who wrote too few zeros for five billion, for the boy who left off "miles," and for the class as she walked around saying "twenty seven million degrees Fahrenheit, twenty seven million degrees Fahrenheit So far, I haven't seen it yet." In the end, she made sure they established common ways of representing mathematical (and scientific) concepts. However, she believed discovery was crucial to effective learning, as she told students:

> Well, I tell them almost the first day the story about the man that was fishing and that there was a poor beggar who comes up and says "Will you give me a fish?" And he says "No I won't give you a fish, but I'll teach you to fish so that you will have fish not just for today but for every day." So we talk a lot about that and how I want the kids to figure out things to do and discover them for themselves cause if they do that, they will have it for the rest of their lives, whereas if I just give it to them, or show them how to do it, it's going to not stick with them, they'll have it today but they won't have it again tomorrow.

This belief in the value of discovery helps explain why this very pacing-conscious teacher took time, even when teaching mathematical conventions, to make room for some discovery. Admittedly, it wasn't "free discovery," but an interweaving of small amounts of discovery with teaching conventions, just as she wove together the excitement of the story with the conventions. This discovery orientation helps solve the puzzle of why, in the decimals lesson, Molly gave the boy who wrote .73 time to realize it was .37, and to write it correctly. Thus, while she sometimes pushed ahead briskly in order not to lose students' interest, she sometimes paused so discovery could happen, in the interest of learning.

Making Circles and Stars

After the sun story, students used protractors to draw half and whole circles. Drawing the same shapes on the overhead, Molly drew a diameter line across her circle, and asked what the line was called. "Separator, a middle line, and line of symmetry" were suggested, and when a student said "equator," Molly seemed amused and said that was what you would call it on a globe, but what would you call it in math? She said all the answers were correct and were great, but the word she was looking for was "diameter," which she wrote down. Then she wrote and explained the words "radius" and "circumference." Again connecting mathematics to something students were doing, she had students mark 0, 90, 180, 270, and 360 degrees on their circles. She was supportive of a student who answered that when you add 90 degrees to 270 degrees you get a whole, but asked what else you could call it, and he answered 360 degrees. Having drawn bisectors from top to bottom and left to right on their circles, they talked about the four right angles in the picture, and discussed how the angles reminded them of a story they had read about angles, with "Mr. Right Angle, Baby Acute, and Uncle Obtuse."

Then Molly asked them if they were ready for some fun, and they enthusiastically said "YEAH!" Drawing a fresh circle on their papers, she had them mark dots at every sixty degrees around the angle. Then she told them to draw lines from one dot to the dot 120 degrees away, and continue to do that and see what it made (a Star of David). She told students they could color these in and cut them out when they finished. As they worked, Molly marked on the overhead dots at every seventy-two degrees around the circle, said she wouldn't tell them what shape this made (a five-sided star), and said they'd have to find out on their own. For a long time, students excitedly drew, colored and cut out their stars. Before ending, she put the original star on the overhead, asked what shape was on the inside of the star, and they correctly answered "hexagon."

Molly's beliefs about motivation. Several aspects of this activity reflect her beliefs about student motivation. First, even with the thematic focus this day on the sun and circles like the sun, there were a real variety of activities, which she believed crucial for maintaining interest.

An interesting example here for motivation was the shape making. The sheer fun of the activity was impressive, and again, the overhead was where the drama began--what shape will this make? However, this time, she let them work it out on their own, so the resolution of the tension, the answer to the puzzle, played out on their own papers. By using protractors and angles to discover how fun shapes are made from angles, students seemed to be discovering that a math lesson could be fun and that the tools and ideas of mathematics could be put to fun and functional uses. Students were having a wonderful time at the end of this activity. In a similar shape-making activity on another day, I caught the playful conversation of two girls whose enjoyment was clear:

Girl 1: Even though it's math ...
Girl 2: It's fun.
Girl 1: It's math along with art.
Girl 2: It's "mart."
Girl 1: It's K-mart.

Molly's beliefs about learning. The discussion of terms for circles and angles was perhaps the most interesting part of the lesson here in relation to her beliefs about learning. Molly was concerned about the inattention of the primary grade teachers to teaching mathematical language, because she thought vocabulary was important to understanding and being able to communicate about mathematics. Using mathematical language also meant operating at the third level of her three-level learning theory. She believed students who got to high school without knowing the correct terminology would be "lost." Thus, Molly attended to the students' efficacy in mathematics, not just for that year, but for years to come.

The logic of Molly's actions was not that students simply needed to be able to say certain mathematics words, but that they needed to understand what they referred to, and what their use was. Some teachers believe that children magically gain understanding simply from touching manipulatives or making a representation like the diameter line (Ball, 1992).

Molly considered the "doing" very important, but knew that the "meaning" of the manipulative wasn't obvious or unambiguous. Thus, in the decimals lesson earlier, she established agreement that they were calling the flat block "one," for the purposes of that lesson. With the circles they drew here, she agreed that words like "separator line" and "equator" were correct, but wanted to know what you call the line that bisects a circle in math. Sometimes, steering students from a science-globe view to a mathematics-circle view was sufficient. However, when a student said adding 90 degrees to 270 degrees gave you a whole, she agreed with this mathematical labeling, but asked what else you could call it, and the student answered 360 degrees. Thus, Molly believed it was necessary to carefully negotiate with students what terms were being used for which referents, so that manipulatives or representations could be usable learning tools.

Main Themes in Molly's Beliefs and Practices

Molly's main goals for students in mathematics centered around broad issues of motivation and learning. To better understand Molly's beliefs and practice, I draw from the examples and analysis above the main themes in her beliefs about students' motivation and learning.

Themes in Motivation

Overall, Molly had various elements in her mathematics practice for keeping students headed in the right direction towards positive motivation. These practices fit neatly with her beliefs, or outcome expectancies regarding motivation. The practices and related beliefs centered on making mathematics interesting and fun, doing the right tasks in the right way, supporting each others' motivation, and helping students learn, so that they didn't get stuck.

The need to head in the right direction. For Molly, students could be headed in the right or wrong direction in their attitude and motivation towards mathematics. To her, it wasn't simply "natural" for students to find mathematics boring. She wanted them to like math and to want to pursue it in the future, but saw many students who disliked it, which had serious consequences: "Liking it, having a good attitude towards math I think at third grade level is terribly important. If they've learned to hate math by third grade they're going to hate it the rest of the time probably." Like many developmental theories (Cole & Cole, 1996), her comments suggested a critical period for developing attitudes towards math, and thus, it made sense that "attitude towards math is something that I really look at." While scholars have debated whether the "spring of action" in motivation is more rational or emotional in character (Ames & Ames, 1984b), Molly's view emphasized emotions, interest, challenge, and success as crucial in affecting present and continuing motivation.

Is it interesting, fun? Central in Molly's view of motivation was whether something was interesting, or fun. When motivation was lacking, the instruction was probably boring. Molly kept acquiring new teaching materials "because I know it captures the kids' imagination and interest."

She made mathematics interesting by linking mathematical content to life, to things students had experienced. Thus, budgies, circles, the sun and base ten blocks all served as vehicles for learning. Not only was mathematics linked to objects and themes with which students could identify, it was interesting because they were actively doing things with it--writing, drawing, predicting, using manipulatives, and acting out problems. Even dry conventions like how to represent .37 were consistently linked to students' actions.

For Molly, a task was interesting when there was something for students to puzzle through or figure out. Her belief that students naturally "like to puzzle through things" is consistent with an intrinsic motivation view of humans (e.g., White, 1959). In this view, humans are believed to be naturally motivated to make sense of things, and learn to do things, so as to expand their own competence. With human nature on her side, teaching with puzzles and games worked beautifully: "even the most turned-off kids get interested." Also, Molly's emphasis on problems that were challenging to students, that they would have to struggle with a bit (e.g., the budgie problem), was consistent with views on how intrinsic motivation is maximized (Stipek, 1988).

Believing that math was fun, Molly treated it as fun, by her interest and excitement, and by her use of dramatic pauses to introduce mathematics, problem-solving, and mathematical facts. In her hands, problem solving seemed like drama. Indeed, good mathematics problems have characters, plot, tension and resolution, but I only realized that by reflecting on Molly's teaching. In their reactions to the unresolved tension of unsolved problems, children showed the strong curiosity that is consistent with theories in which curiosity plays a major role in children's intrinsic motivation (e.g., Berlyne, 1966).

Molly also believed math could be enjoyable because it was creative. Thus, students had to create ways to solve problems such as when they didn't have enough people in each group for one of the "act it out" problems. Molly also accepted and encouraged creativity in answers: "if you have a perfectly good answer I will accept it, I don't care what the textbook tells me is the correct answer." Mathematics could be creative in other ways, as on a day when students wrote their own mathematical "dramas," inspired by their reading of the story "The Greedy Triangle." Molly excitedly showed me the creative stories students had written, with wonderful pictures of cartoon-like shapes, and funny stories about what happened to them. In one story, a triangle wanted two more angles, and asked a man to give him two more and the man said "no" and then the triangle found a fairy who gave him two more angles and he lived happily ever after as a pentagon. A girl who saw me looking at the stories proudly showed me her story, whose plot involved paying money to the "shape changer." I felt this kind of creative experience in mathematics was not just interesting, but even whimsical, and thinking of math as whimsical was a new experience for me too!

Beyond all this, Molly directly said mathematics was fun. This always felt authentic, not the product of a workshop exhorting teachers to "act interested." Molly's genuine interest and excitement came through in her teaching.

Do the right tasks right. Many teachers talk about motivation as a characteristic children have or don't have, but Molly talked more about tasks that students would or wouldn't want to do. Games and puzzles had the characteristics students found appealing: "They do love to get together and do those things."

However, one still had to do puzzles and games right to support students' motivation. Pacing was crucial, and Molly believed part of her success resulted from the "pretty fast" pace observed, since going slow was boring, especially to bright kids like hers. Believing that it held students' interest, Molly made problems more interesting by using the magic of the overhead as a site for students to represent problems, answers, and illustrations of problem-solving processes.

Molly believed variety was key to interest as well, and provided variety in many ways. For example, in the problems on the day of the budgie problem, there was variety in topics (birds, butlers, checkers, friends and parties), and participation formats (solitary and group work, groups presenting problem-solving processes, and comments from Molly). Within lessons, there were a variety of tasks (building models, reading, writing, predicting, listening, and drawing). Across a week, she alternated between types of activities--arithmetic on one day, "math lab" (activities done in small groups, with rotation between tasks) on one day, and three days of "more the hands-on, exploring kind of thing." Across the year, students learned different content and different strategies for solving problems. The novelty wore off if you did too many problems, even if they were good ones, Molly believed. Thus, on the day of the budgie problem, they only did four problems. As in good drama, Molly didn't take too many bows. Molly's emphasis on variety, and the novelty it provided is consistent with intrinsic motivation theories in which humans are believed to experience moderately novel stimuli as pleasurable or enjoyable (Berlyne, 1966; Hunt, 1965; Kagan, 1972).

Don't get stuck. Molly believed that learning, so you didn't get stuck, was also important for motivation. Though she de-emphasized computation, she believed students really should learn their multiplication tables. Interestingly, she said they should learn "math facts" not because she saw computation as central to the third grade mathematics curriculum, but rather, so they wouldn't lose motivation:

> It takes kids forever to do math if they don't know that seven plus three is ten. It just takes them so long. And then that's one reason that kids learn to kind of get turned off, if every time they come to a math problem, they have to figure it out.

Similarly, teaching students problem-solving strategies helped students from getting stuck, and moreover, helped them not get stuck thinking there was only one way to solve problems. She also had students share the strategies they created to solve problems, giving students even more tools for not getting stuck in the future. Thus, to Molly, knowledge and skills were cognitive tools for maintaining motivation, thus making progress and success possible.

Themes in Learning

In sum, Molly believed that having particular elements in her teaching practice helped students keep moving in the right direction--towards reasoning, problem-solving, understanding, and communication. Among these teaching elements were doing the right sorts of tasks, learning through discovery, and learning from others.

The need to head in the right direction. For Molly, students could also be headed in the right or wrong direction in learning mathematics. She pointed out the different directions learning can take: "Many kids can learn the number facts and still not be understanding, and other kids have very excellent understanding of math and don't know their number facts." To be headed in the wrong direction was learn only math facts and only one way to solve problems. Thus, on a list of "Eight Math Myths" posted on Molly's wall, one myth was that there is only one way to solve a problem. A statement on a parent handout predicted that the traditional orderly and logically sequenced teaching would result in "severe learning failure for most" learners.

In contrast, to be headed in the right direction was to learn problem-solving skills and the conventions for writing and talking about mathematics, to understand mathematics, and to be able to communicate that understanding. She explained what she valued: "Well I think that reasoning, thinking, problem-solving are far more important than being able to give the math facts back to you real quickly and not knowing why they are doing it or how they're doing it."

Do the right sorts of tasks. The doing was clearly important in Molly's beliefs about learning, and working with manipulatives was crucial for building understanding. Learning also was remembered better when it involved action, not just talk: "I think it sticks with kids better when they do something rather than just talk about it." However, it was important that the doing was also meaningful. Thus, she frowned on students simply memorizing the multiplication tables, believing such learning was easily forgotten, and explained to parents how students would really learn them: "They'll know them by using them in a meaningful situation." Students certainly listened and watched in Molly's class, but periods of listening were short, alternating with other types of doing--writing, using manipulative, discussing problems with others, predicting, and drawing.

To begin with, students needed meaningful problems to puzzle about in order to learn problem-solving skills:

> Problem solving is something that is going to puzzle a child when they first look at it. They wouldn't see the answer immediately. They'd have to work at it and you could see these kids [working at it] when they were doing that budgie problem.

Struggling and puzzling were important components of those experiences that built dendrites, or brain capacity. Molly believed the budgie problem was worthwhile because it was "real hard for them to know what strategy to use," and took maturity and experience to know how to approach such a problem. Counting both maturation and experience as key to learning was one way her beliefs were consistent with a Piagetian perspective (e.g., Ginsberg & Opper, 1969).

To Molly, another of the right sort of tasks was writing about mathematics. Consistently, students were asked to write or draw something that represented the mathematical ideas at hand. Molly believed writing about math helped students identify what they didn't understand. Thus, they wrote stories, wrote about their favorite math problems for their mathematics portfolios, and wrote (in words and/or symbols) how they worked out problems. Students also sometimes wrote what they knew about a topic before and after the unit on it. She believed having students write what they knew about a topic before the unit on it helped them learn better by helping them focus:

> To me, when you do this as [a] pre-test, they focus on what it is we're learning. Otherwise they don't know what you're talking about. You're just another day in school you know and it's just sort of a jumble in their minds.

Molly believed communication was a very important part of mathematics. She believed that learning to explain oneself was important for communication, but also aided understanding: "when they make themselves clear, they're clearer in their own minds." Thus, students were constantly explaining to others what they did and how they did it.

Allow for discovery. Molly also valued discovery, and believed it aided understanding, and the ability to remember and apply knowledge. Even when correcting students about accurate and complete representations for concepts, she gave only as little help as was necessary, letting them discover the answer as much as they could. Despite her concerns for pacing, she did this even when simply telling the answer would have been faster. Consistent with a Piagetian view (e.g., Kamii, 1990; Labinowicz, 1980), her emphasis seemed to be more on students' learning and learning from errors, and taking the time for them to construct understanding. By not starting with the correct model, and not swiftly correcting all mistakes, her approach was inconsistent with behaviorally oriented, direct instruction approaches in which extinction of errors is a key objective (Alberto & Troutman, 1990).

Molly's discovery orientation also helped explain why she didn't squeeze more learning out of some activities, as she seemed to believe they could discover more in time, with further experiences and her guidance.

They learn from each other. Also consistent with a Piagetian view of learning from one's peers (Labinowicz, 1980), there was a lot of student interaction and discussion, which Molly believed was very important for learning. She didn't consider herself to be the source of all knowledge: "I think the kids know things that I don't know." During games, Molly noted that "most of the kids are pretty good about teaching their partners," and she wasn't sure whether they learned more from her or from each other in these situations. One day I watched a student struggle to explain to the class how to compute a batting average. Molly didn't know how to do it, and was happy to rely on the student to do this, though she helped him with how to communicate about this to the class. Students also learned each other's problem-solving approaches: "we take the ones that are successful, I take those different ideas and I show the kids the different ways that they've solved the problem." This process brought together her emphases on learning by doing, by discovery, from others, and through communication.

Keeping an Eye on Both Motivation and Learning

Molly believed it was important to support both motivation and learning simultaneously, and her teaching was clearly designed to support both. At times she seemed to be doing a balancing act, trying to get as much learning out of an activity as she could while still allowing for discovery and maintaining momentum and motivation. Ending the budgie example without providing an answer illustrated this balancing act. On another day, Molly ended a science writing activity without resolution. "I really wanted them to do a good job, but yet, it was going on too long and some of the kids were gonna' get restless." Moving on also served the interests of learning, since she felt there was so much to learn, and so little time: "I never feel like I get finished. I feel like I'm always hurrying the kids--Come on! Come on!"

Left behind when she ended activities without the resolution of a correct answer was an unsolved puzzle that could provide both motivation and learning on another day, as students would continue to pursue mathematics, and learn.

However, motivation and learning were perhaps more interrelated in her beliefs than the analogy of a balance suggests. Motivation and learning seemed quite intertwined for Molly. Learning problem-solving skills was prized because skills could help motivation in the future, which could lead to more learning, and so on. Writing about what they knew about a topic before a unit on it helped them pay attention better (a motivational issue), which in turn aided learning. Remarkably, computation was of secondary importance to Molly--except that knowing your math facts prevented you from getting bogged down and losing motivation. This close relationship between motivation and learning was indicated by the handout she gave to parents, which stated how enriched experiences that were "associated with enthusiasm" by the learner result in brain growth and greater intelligence in students. In this sense, Molly was indicating that any really mind-stretching activity had to be enriched in terms of both learning and motivation, simultaneously. For Molly, both motivation and learning could be found, together, in working out doing puzzles and playing games.

Overall, Molly's beliefs, or outcome expectancies regarding motivation and learning were coherent, and her teaching practices were very consistent with her beliefs.

Molly's Motivation: Alternative Energy Sources

Molly said teaching this way took guts, so I asked her why she taught this way: "Well I think it's fun. I get enjoyment out of it. I like to see the kids doing things that they're intrigued with and they're interested in." Given the energy-intensive nature of such teaching, I still wondered how she did it. So I asked where she got all her energy from: "Oh, the kids. Yeah, I get it from the kids." I asked how she meant that: "Well, I mean, they're enjoying what they're doing, you know, and so it's just a positive feedback, I guess." Molly put great effort into teaching, was energized by the students' enthusiasm for the lessons she created, and she reinvested that energy right back into her teaching, and the positive cycle continued. Such reciprocal effects are clearly consistent with interactionist theories of development (Bandura, 1981; Bronfenbrenner, 1976).

I turn next to examine issues regarding her efficacy beliefs regarding teaching mathematics the way she did.

Effectiveness Depends on Teaching Methods

We have begun to answer my first guiding question for this study: What was the nature of Molly's efficacy beliefs regarding her mathematics teaching? Next we look more directly at her beliefs about the impact she could have on students in mathematics, and how those related to her experiences with reform-oriented and traditional teaching methods.

I Make a Difference

I asked Molly to think about her own mathematics teaching in answering the second teacher efficacy question from the Rand studies: "If I really try hard, I can get through to even the most difficult or unmotivated students." Her response was "I would say one, I think I can." Thus, Molly's personal mathematics teaching efficacy beliefs can be characterized as very positive and direct, as indicated by her "strongly agree" self-rating and her direct response on this measure.

Her positive sense of mathematics teaching efficacy was evident in her practice as well. For example, during math one day she reflected on students' work from the day before: "Now a lot of you made mistakes and I think it's because I didn't teach you good enough." Asked later how often she believed students' failure to learn reflected some inadequacy in her teaching, she noted: "Oh, think it's always [true]. If a lot of them don't get something, I haven't communicated it right." If a few kids didn't get it, she might think they didn't listen, but if many kids made the same mistake, she assumed it was something she needed to do over again or teach differently. Believing that when students don't learn, one can do something to help them learn is a characteristic indicator of positive personal teaching efficacy beliefs.

I examine next her efficacy beliefs in relation to using reform-oriented mathematics practices.

The Efficacy of Reform-Oriented Practices

They like math. I asked Molly to explain why she gave the rating of one on the Rand item asked regarding personal mathematics teaching efficacy. Her explanation focused first on students' liking of mathematics, was clearly linked to reformed teaching, and contained some of the key elements of her beliefs that I noted earlier:

> Well I think when you take the game, hands-on approach that even the most turned-off kids get interested. Kids like games. They like to puzzle through things. It's just sort of part of their nature, and that's why I teach the way I do.

How students felt about math was the first thing Molly mentioned on another occasion when I asked what she could impact in mathematics: "Well, I can make an impact on their attitude towards math, for instance."

Molly pointed to students' day-to-day interest in mathematics as evidence of the effectiveness of her reform-oriented approach in eliciting student interest and engagement. She pointed out "I don't ever have anybody that says that I don't want to do math, I don't like it, I hate [it]." Also, students had written in their math portfolios about what their favorite math problems were, indicating that this approach made math likable, not simply something to endure. She also noted how her students were "absolutely astounded" that only one student in their exchange classroom from Idaho cited math as a favorite subject, since in her classroom, many students picked mathematics as their favorite. Interesting in this regard was how her students were even surprised that few students chose math as a favorite subject, suggesting they had developed an expectation that others would like mathematics.

While Molly never defined "fun" for me, the smiles and excitement during the act-it-out problems seemed to reflect fun, as did students' reactions when making stars, and during other activities. I know it was fun for me to watch. With this reformed approach, Molly and her students got into a pattern of seeming to feed off of each other's enthusiasm: "They're always interested. And I think when the kids are interested, then the teacher's interested and vice versa." This suggests that students were actually a motivational resource for Molly, both for her choice of teaching approaches and for her persistence with this energy-intensive approach.

The evidence of Molly's personal teaching efficacy in helping students like mathematics may have been even more striking in a school like Timberside. That is, many students came to her already disliking it, but often cited it as their favorite subject by the end of the year.

Look at how much they learn! Molly had a great deal to say about students' learning and the positive impact of reform-oriented teaching on student learning. She cited various indicators of the impact she had on students learning of mathematics, including traditional and more reform-oriented measures.

First and foremost, Molly knew her students were learning when she taught this way, because she was tuned in to their current understanding: "I don't have to give a test to know if the kids know what they're doing or not, 'cause I evaluate all the time. It's just part of what I'm doing."

Also, despite calling the ASAT "old-fashioned" assessment, Molly was pleased that "my kids consistently test very high in math on that test." However, she took almost as much pleasure in the pattern of results for the three parts of the test (computation, math application and math concepts). Scores in those areas "were all high, but of the three, the computation was the lowest, which pleased me, 'cause I'd much rather the concepts were high than the computation." Walking through individual students' decile scores with me, she noted more of her students moving up a decile or two over the previous year than there were students who had dropped a decile. Molly thought the ASAT was a valid measure of some things in mathematics. She didn't teach to the test, but believed there must be an overlap between the test and her teaching, and that something she was doing "has an effect on their scores."

Molly also pointed to students' writing in their mathematics portfolios as clear evidence of the effects of her teaching. Before the beginning of a unit on ordinal numbers, she said most students wrote: "I haven't the foggiest notion what it is, I have no idea." What they wrote after the unit was a different story: "Most of them knew what it meant, what it was then." She pulled out one girl's portfolio one day to show me evidence of a student learning from instruction. Before instruction, the girl wrote, "When I round in math I don't know," but three days later wrote, "When I round in math I go to the nearest number," and the girl wrote several clear examples of how this worked. Molly said such evidence "is much more meaningful" regarding learning than filled-in blanks on workbook pages:

> To me this is much more valuable than giving them a problem and saying "round this number to the nearest ten," cause I know she understands it. There isn't any doubt in your mind, is there, that she understands what rounding is now?

A third source of evidence was the chapter tests from the math text. Molly gave these although it was against her better judgment, and even though she hadn't taught much from the book. She cited student scores on these tests as evidence of learning, pointing out that almost all the students in her class got a "B" or better.

Molly also cited improvements in the CLAS scores at Timberside as evidence of the efficacy of reformed practices, attributing this gain to other teachers "gradually getting more into the swing of this kind of writing and explaining your thinking and so on." More specifically, Molly pointed out that Peggy Turner and Beth Schmidt had both tried "math lab" activities they got from Molly, and found that students were both learning and liking mathematics.

I also asked Molly what parents, principals, other teachers, and people from the district office would say about the impact she had on students in terms of mathematics, if they had seen her teaching that day. "Well, I think they'd probably be surprised that the kids had a basic understanding of what a quadrilateral was and a polygon and an acute angle, and so on. I think they would be." She described such evidence of learning as having "a lot more meaning than sitting down and writing answers to a math problem in a book."

Overall, Molly clearly believed her use of reform-oriented practices had improved her impact on students' learning of mathematics. Thus, when I asked if she always felt highly confident in her ability to impact what they learn in math, she noted:

> Well I think I feel better about it now than I used to, because it used to be we had to stick more closely with our textbook and I think there's more of an impact when you can get away from the textbook and do the hands-on kinds of things with kids.

Molly's perceived impact on students had limits, as her goal of helping students learn to use math meant she had to give up some effectiveness in teaching computation. However, this didn't bother her: "I kind of push that off on the parents." She also didn't believe that she reached every student in every lesson, though she noted that if she went back and had students write down what they were doing, "usually they'll come back and they'll get it [the concept]."

Molly Explains Why Reformed Practices Work Better

Very simply, many of the effects Molly valued and had on students were only possible using reform-oriented mathematics teaching practices. Teaching this way enabled her to help students learn the skills of problem solving and communication, and learn to be creative with mathematics. She believed manipulatives were central to understanding, as part of the three-stage theory of learning she believed was universal: "this would [even] work with retarded kids." Thus, teaching mathematics in a reform-oriented way allowed Molly to affect students in many more ways than she could have using traditional practices. I turn below to explore how a few of the other reform-oriented practices were related to her feelings of efficacy and efficacy beliefs.

Learning from others. Molly observed that students might learn as much or more from each other as from her during group games and other peer-peer learning. This raised an interesting question regarding her feelings of efficacy. I asked what this meant for the credit she could take for student learning, and she noted: "I don't know. I take credit for it because they wouldn't have it if it weren't for me starting it, but they do help each other a lot." Thus, just as Molly utilized students as a motivational resource, she used them as a teaching resource. While students also experienced "teaching efficacy" in Molly's room, she believed she still had an important influence.

Learning with calculators. Molly said calculators would be the second things she would want to have if teaching math on a deserted island. She gave examples of how using calculators allowed students to do "higher-level" work with protractors and angles and problem-solving: "It's much more brain stretching, mind stretching to do things that are more complicated and not have to worry about the computation part of it if they have a calculator." Some teachers believe students won't learn math if they use calculators, and should learn computation first. Molly disagreed with this, and felt calculators let her have more of an impact on students "Well I don't think there's any limit on what they can learn. I mean, they can do fifth and sixth grade math if they can do that with a calculator."

Learning by writing about math. Molly thought writing played an important role for students' understanding. On a few occasions, Molly talked about how writing helped students identify and overcome misunderstandings: "When they have to write it down, they realize they don't know it and then to later write down, they really truly understand it." Also, having students write about what they knew about a topic before the unit assisted learning, by helping them focus better on what they were supposed to learn.

Writing played an important in Molly's efficacy. Saying repeatedly that she always got "a lot out of their writing" about their understanding, students' writing aided Molly's ability to teach for understanding. Students' writing made it possible to be more responsive to what students knew, because it helped Molly learn more about what they did understand, and "I think you do find out more of [what] they don't understand."

The Traditional Approach Just Didn't Work for Her

Making math dull. Molly's impressions of the effects of traditional practices on liking mathematics were all negative. She said students would groan when she taught in the traditional way, using the textbook, and that these were usually the only when she would "lose" kids during lessons. Molly also didn't find traditional teaching interesting, so she didn't do it often.

Her experience was that traditional teaching hurt students' attitudes towards math and towards school more generally. In particular, Molly cited the heavy emphasis on computation and the repetition found in the EXCEL program as "a way to teach kids to hate math." Describing it as something that went "out with the dark ages," she thought it was boring to students, because "it's the same identical pattern, day after day after day." Molly's point about the deadening effect of too much repetition reflects the basic learning mechanism of "habituation" (Berk, 1996).

Too little learning, and the wrong kind. Molly believed that a more traditional teaching approach worked less well, and worked only for computation and traditional content, which she considered somewhat peripheral. Molly worried that in using a traditional approach students might learn their math facts without really understanding. Also, traditional practices simply didn't address problem solving, communication, understanding and creativity and other areas Molly considered important.

Molly gave an illustration of how the traditional approach didn't result in the problem-solving skills she valued. She had her children do the "How Old is the Shepherd?" problem (Merseth, 1993). The problem states that there is a shepherd who has a certain number of sheep, and has five dogs, and then children are to figure out how old the shepherd is. As Molly noted, three out of four children in Merseth's research produced a numerical answer, and most of Molly's children also came up with numerical answers. While she was interested in her students' reasoning on this problem, she thought that if Timberside' math program was stronger in problem solving, most children would have handled the problem better: "I think they would sit back and look at that one and say it's impossible, you can't do it. There isn't any data there that would make you understand how old he was."

Molly also believed traditional practices didn't lead to understanding. Thus, she criticized the practice of a primary grade teacher at Timberside, who was a mentor teacher for the district and was seen by other primary grade teachers at the school as a leader in mathematics. Molly said that teacher covered a lot of math skills, but Molly didn't believe that her algorithm-oriented approach led to understanding: "If you ask the kids what they're doing, they probably more than likely couldn't tell you." Molly just didn't believe the brain benefited from experiences that involved "constantly sitting down with a ditto."

Furthermore, Molly had found that the traditional practices of her peers often resulted in student misconceptions--that there is only one way to solve a problem. This effect of traditional teaching certainly was more salient to Molly than it would have been in a school filled with like-minded peers.

In sum, Molly attributed her success to the use of reformed practices, but didn't believe traditional practices were effective, and didn't have as much success when using them.

Achieving Efficacy, Together and Alone

One of my initial guiding questions focused on understanding relationships between efficacy beliefs and reformed teaching "in light of the multiple contexts in which these teachers carry on their work." To better address that question, we examine next how social supports helped make such a story possible. I weave through this section how Molly elicited this support, and then conclude with a section on the importance of Molly's own efforts.

Getting By with a Little Help from Her Friends

Molly was helped to teach in a reform-oriented way and feel effective when teaching this way by a supportive policy climate, the support of administrators and parents, the teaching tools available to her, and by having very good students.

History and policy were on her side. Overall, Molly saw the national dialogue about the changing world, and preparing students for the twenty-first century as supportive of her kind of teaching. She thought the national direction in mathematics education was linked to how our society is changing. She said the problem with the Hubbell space telescope was due to "a communication gap between two groups working on it," and cited this as evidence of "how terribly important it is that people learn to communicate with one another in our technological world that we have." In order to be effective, Molly believed mathematics teaching needed to change along with a changing world. For example, she believed students should be able to use calculators to solve problems partly because calculators were going to be "as common as forks."

Molly was a member of the California Council of Teachers of Mathematics, attended conferences of that organization, and had read the first two NCTM Standards documents, and the 1989 and 1992 California Mathematics Frameworks. She explained how the main emphases in mathematics education statewide and nationally were communication, reasoning, and problem solving, and gave examples of how her own teaching reflected these emphases.

Noting its emphasis on reasoning, problem-solving, and communication, Molly believed the CLAS test reflected her approach, and was moving other teachers towards reform-oriented teaching: "And, you know, tests drive the school district, and the CLAS test seems to be driving people to realizing that they've got to do this problem-solving approach to math." Even after the CLAS test was discontinued due to political pressure, Molly expected the reform of teaching to continue, because of "the National Council of Teachers of Mathematics standards, you know, that push that's forever behind it." She believed the SAT had been re-configured in ways similar to the CLAS, and noted how calculators and changes in assessment were changing mathematics education: "As we are evolving in our testing, computation is not going to be the 'biggie' anymore."

Molly believed the Southdale district office was supportive of the mathematics reforms, and highlighted the importance of the district's support of reform-oriented teaching:

> Part of the thing is that we now have more stuff to teach with than we used to. We used to have textbooks and you had to teach with textbooks. That way, if you didn't teach with the textbook you'd be in big trouble and ah, and now they're encouraging teacher to get away from the textbook. So I think I've basically kind of always taught this way but I've felt more of a freedom to do my own thing.

However, because of the ongoing budget crisis in the district, with millions of dollars being cut from the budget each year, the central district office was capable of neither substantial supervision nor substantial support of the movement towards reformed mathematics teaching.

Principals supporting Molly's principles. Both of the principals at Timberside during this study were very supportive of reform-oriented mathematics teaching, while allowing for teachers to use more traditional practices if they chose to. Both principals supported reform-oriented math teaching through sending teachers to workshops, buying manipulatives for classrooms, supporting the Family Math program Molly led, and distributing information on this approach to mathematics teaching.

Both principals told me that Molly was an exemplary mathematics teacher, and during staff meetings, she was sometimes asked to share her ideas about teaching math. One of the principals also gave Molly strong support when a set of parents had sharply criticized Molly's lack of emphasis on computation.

In turn, Molly made it easy for the principals to support her--given her dedication and professionalism, and excellent student outcomes. Molly may also have been easier to support because her approach to reformed teaching was not radical--she still taught a lot of traditional content, even if computation was "taught" with parents' help.

In a different era, the principals might not have supported any of this and might have required Molly to teach a computation-oriented program like EXCEL. Thus, administrative support was important, since even Molly said she might go back to a little more traditional teaching if the principal "really wanted those computation scores up high." Clearly, this would have impacted Molly's feelings of efficacy.

The helping hands of parents. With around 200 parent volunteers at the school, I heard from everyone that the level of parent involvement at Timberside was amazing, and it seemed especially high in Molly's class. Molly pointed out that Timberside drew students from a very affluent area, with lots of professional parents who supported education and their children's learning at home.

Parents helped Molly greatly in several ways. Assistance was needed for pulling off the logistics of some of her more interesting activities. When the class did math lab, parents worked at three of the centers, and Molly worked at one--"Of course I plan it all, but it really helps." Parents also helped with organizing and checking homework, and did most of the work with students on computation--at home. Molly helped parents help her by sending home flashcards and other materials parents could use: "And parents love having something to work on with the kids and they give them flashcards and they get all kinds of stuff to go along with it. So I just let the parents worry about it." By subcontracting out to parents most of the work on computation, Molly could focus class time on reform-oriented mathematics teaching.

Parent groups raised money too, support Molly deemed "really important" for buying books, games, and learning activities. Molly and other teachers received $400-$500 annually from the parents' gift-wrap sale, and the PTA sometimes gave more ($100 in 1995). Molly also got money for having gifted students, and approached her parents directly and got another $40-$50 per student from most parents.

Of course, Molly was not coasting to retirement, and had the kind of interesting practice a parent would understandably contribute to. In describing the impact she could have on students more generally, she noted: "I have lots of parents that come in and say, 'Oh, my kid loves school this year and they hated it last year.'" Molly also made some accommodations to parents. Thus, she noted that the chapter tests from the mathematics text, which she "gave against her better judgment," helped "parents feel that the kids cover these things--they like to see a test come home."

Overall, Molly's practice both relied on and elicited high levels of parental involvement and satisfaction. Parents' satisfaction with Molly's teaching and student outcomes meant there was rarely pressure for her to revert to more traditional teaching: "You just have to realize that most of my parents who come in are extremely happy."

Finally, my other impression, verified by Molly, was that her students came from homes where learning was clearly valued, and in this sense, parents may have made their most important contribution to Molly's practice. The importance of this was highlighted when I asked whether she ever had students she couldn't reach. She seemed on the brink of answering "no," but then talked about a particular boy she had in class:

> I have no cooperation from her [the boy's mother]. He doesn't ever do his homework. I feel like I'm wasting my time worrying about him, because there's no carry-through. He doesn't have any ambition. He told the aide that he liked, she said, "Well, what do you want to be when you grow up?" He said, "Well, I wanna' sit and watch television, like my uncle." I just felt like I had no impact on him at all.

Her comments about this boy highlighted the crucial role of parental influence on students: "I can't do it alone and if he doesn't wanna' do it and his mom doesn't care, then I, I just can't, but most of the kids in my room--their parents really care." Thinking of the many students similar to this one in Phoebe's classroom, I asked Molly what she'd do if she had an entire classroom of students like him. She laughed softly, and said, "I don't think I'd still be teaching," noting that it would be just too "discouraging."

This reminded me that even those teachers who feel highly effective cannot, and do not, do it alone. This student didn't seem to value school learning as the other students did. With this ingredient missing, she felt she couldn't reach or impact this student. However, such a case of non-support was rare in Molly's case.

A cornucopia of teaching tools. The substantial funding Molly received had led to an impressive and increasing wealth of books, newsletters, games, manipulatives, prepared overheads and handouts, and other tools--calculators, crayons, drawing paper, protractors, etc. Thus, she could say of her practice a statement quite rare for teachers: "This is ridiculous--I don't need anything else."

Molly's referred repeatedly to her collection and use of commercial resources from Marilyn Burns, AIMS, EQUALS, Marcy Cook, and many others. These materials were crucial for Molly in providing this "reformed" teaching practice that had these wonderful effects. Such materials also helped her cope with the unpredictable flow of teaching: "If there's a time when I've got ten minutes and I don't have anything planned, I can just turn around in the room and find something fun for the kids to do, [because] I've just got so much stuff." When asked what she would miss most if asked to teach on the proverbial deserted island, she remarked about the commercial materials: "Well, I'd miss them too, because, I mean I don't look at myself as being a real creative person. I get ideas from other people."

Molly's practice and her efficacy beliefs evolved as publishers created new teaching materials and she learned how to use them. Thus, as she was learning to use a rubric for scoring students' problem solving, and planning to use it more in the future, she anticipated further improvements in students' writing about and understanding of mathematics. Similarly, in the first year she used mathematics portfolios, she described that as "sort of an evolving thing with me."

Molly's self-motivated and capable students. Typically, 24 to 28 of Molly's 30-32 students had been identified as gifted and talented (GAT). She said that teaching her students was made easier because they were so independent and self-motivated: "Oh yeah. I don't have to say anything to them. I think I could walk out of the room for fifteen to twenty minutes and they'd probably keep right on going." I saw evidence of this on two occasions, as Molly went into an adjacent room for 20 minutes to work with small groups of students, and the students remaining in the classroom kept right on working as if she was still present. However, such self-regulated learning didn't just happen. Molly said the students weren't that way at the start of the year, and explained her role in the change:

> Yeah, partly they mature and partly it's experience on my part. You know, but they always have something to do. And I always tell them, "There should never be a time when you don't have something in front of you to do," because they've always got this book ...

Whenever students finished an activity, they knew what they were expected to do. If they had no other unfinished work to complete, they were to read a book. Molly had a bookrack in the room with well over a hundred books, and noted "they choose their own books, so it should be a book they like." Molly used some of the time when students were thus engaged with miscellaneous work or reading to give a little individualized instruction to individuals who were struggling with some aspect of math (or other topics). This extra help probably made it somewhat easier for her to maintain a brisk pace during whole-class activities.

Having a class that was homogeneous, that cared about learning, and that was very capable meant that Molly could move quickly. Students caught on quickly, and so Molly could cover both traditional and reform-oriented aspects of mathematics in the same day. Furthermore, because most of Molly's students were identified as gifted, and most would go on to another gifted program, she was insulated from the demands of preparing them for the next level of the EXCEL program.

Overall, from the national, state, district, school, and classroom levels, Molly was getting clear material and moral support for precisely the kind of mathematics teaching she was doing.

How Molly Made this Happen: Behind the Scenes

It would be easy to conclude that Molly's success was simply due to all the social support she received. However, her story stood out even at Timberside and even within the gifted program. As we'll see in Peggy's case, not all the teachers at Timberside had high levels of parent involvement. Also, some teachers used their money differently than Molly did, buying, for example, the expensive EXCEL program. Even one of the mentor teachers in the gifted track at Timberside used EXCEL. Also, despite the high-ability students Molly had, these students looked very different at the end of a year with Molly than they did at the beginning, in a number of ways. Thus, we conclude the case of Molly McCarthy by examining how she contributed to her own success.

Building success over time. Molly worked hard to build the teaching practice described here. She typically arrived at school one hour-and-a-half before school, worked for half an hour after school, and worked every night at home, reading papers and planning. After three decades of teaching, she was still rebuilding her practice. Much of what she was doing was new to her practice in the previous five years. Molly kept acquiring new books and activities "because I know it captures the kids' imagination and interest."

Investing time daily, and investing it over a long period of time were both crucial for Molly's success. I asked her how she had the time to keep up with and learn to use new teaching materials:

> Well I've been teaching a long time, that's part of it. And I enjoy it. That's part of it. I don't mind sitting up, I took this book home and read it through and I enjoy doing that. But it does take time, it does take time and there again, a lot of people aren't willing, they have little kids at home, I don't. My kids are grown. And they just don't have time to spend with it, so it's easier to teach the old-fashioned way.

Having had the time, and having built this successful practice, most of Molly's parents were happy, and she could shrug off the comments of two parents who complained because of her lack of emphasis on computation: "you can't win them all."

Playing to her strengths. Molly arranged things so that she could specialize in subjects she enjoyed most and felt strongest in--math, reading, and science. She wasn't strong in music or art, saying, "If I had to plan for music and teach music all day, I wouldn't. I would quit." Thus, she didn't teach a lot of music, and often, the parents provided "really wonderful art lessons" for her students. She also spearheaded the creation of the science lab for the school, which meant that the science lab teacher provided parts of the science teaching. Thus, Molly reduced the teaching burden on herself by letting others carry part of the load, and also through her interpretation of the teacher's role: "Every teacher has their strength or passion--what they really like to teach, and that's what they should teach because that's what they're best at." Noting that she wasn't as effective in social studies as other teachers because it wasn't her passion and she didn't invest the time in it, she simply hoped her students would have a teacher next year where "social studies is that teacher's passion."

Helping others help her. Molly was proactive in making it so that parents supported her type of mathematics teaching, and so that students were able to participate fully and successfully in it.

Molly founded the Family Math program at Timberside and led it four times a year. It was so popular; they had to limit the attendance. Molly used the program to help teach parents about, and persuade them about the new approach to math: "They're coming around. By and large, the parents are beginning to realize that we like them to think about math rather than just do it." Since most parents coming to Family Math were parents of children in the gifted program, Molly had an even better opportunity to influence her students' parents. Partly as a result of the efforts of Molly and others, Molly thought that most of the parents at Timberside were "pretty knowledgeable," and recognized the value of the reform-oriented approach to teaching mathematics.

Molly helped students function well within her kind of teaching by being quite skilled with general features of pedagogy--dealing with transitions, having materials and papers distributed and collected, etc. She did these, or more often, had students do these, in a very efficient and seamless way. Thus, students were a key resource for carrying out the logistics of teaching.

Even with her high-ability students, Molly helped elicit the high levels of engagement seen earlier. In September, "certain leaders" had their hands up because they were the ones who answered questions in earlier grades, while about half of the students would "just sit," because they were "just not used to participating." Molly got them all involved by calling on students based on whose name she picked from a deck of cards of students' names. She told them at the start of the year: "I rarely call on kids whose hands are up. So you all have to be responsible. And I expect you all to be listening."

You gotta' have faith! Molly had acted on her deep belief in the effectiveness of reform-oriented approaches, across various subject matters. For example, she had committed to the reformed approach to language arts, even though she was "schooled" in the need to use traditional methods, and was "concerned" about how her students would do. Her faith paid off: "Their language scores from the ASAT were fantastic. I really couldn't believe it. So it does work. It does work but you do have to tear yourself away from this teaching to the textbook thing." She cited similar evidence of how the hands-on approach to science was improving student learning, even for low-ability students at the school. Again, motivation and learning were connected as she explained why this worked: "It's a way of teaching that's appealing and turns kids on."

A dash of courage helps. I asked Molly what it took for a teacher to move away from following a textbook, to teaching math this new way: "Well, I suppose you have to be a little bit gutsy. You know, I fail, often times I do things wrong." She explained that "you have to be willing to make a mistake and admit it the next day." I observed that she seemed comfortable making mistakes, and wondered what she attributed this to. She noted: "Well maybe because I've taught a long time. And I know nothing horrible is going to happen."

Molly thought other teachers shied away from the reformed teaching because "they just don't want to think on their feet," didn't "have the confidence in themselves," or felt threatened if they made a mistake, or were worried about losing control of the class. As for Molly, the decision to forge ahead with reform-oriented practices was an easy one, despite the risks:

> So I think you have to have a little nerve, probably, to try some of these [new methods]. But once you get into it, it becomes so much more fun, that it sort of feeds on itself, and you want to do it.

Whistling while she worked. Molly made teaching mathematics fun for herself. One day, she showed me the book by Ohanian (1992) entitled "Garbage Pizza, Patchwork Quilts, and Math Magic." She said it was "stories about teachers who love to teach and children who love to learn." Molly "saw herself" in the book, and suggested I read it before I wrote my dissertation. I read it, and also saw Molly in it--as a teacher who loved teaching mathematics, and made it enjoyable and interesting for her. Characteristically, Molly had read the book expecting to get ideas for teaching mathematics.

Asked if she would ever stick with one way of teaching once she got 180 terrific ideas for the school year, she noted "I don't think so, because there's always something new and different coming along--something that I think is fun."

Losing her self in her work. Molly seemed utterly absorbed in thinking about students and teaching; she focused very little on herself. Repeatedly, her answers to questions I asked about her beliefs about herself would begin by being responsive to my focus, but would drift to talk about students, and learning, and teaching ideas. She wasn't defensive at all; she was just less interested in her self than in teaching and learning.

Molly also rarely seemed to worry about her knowledge or performance. She said she rarely focused on how she was doing during lessons: "I don't spend a whole lot of time thinking about it because I'm so busy doing it." She sometimes didn't know about things that students brought up during lessons, but that didn't make her anxious, "It made me curious." If a lesson "goes over like a dud," she would just change it and try it again. If she taught something wrong, or students didn't understand: "I just go back and do it over again. I don't worry about it. I just do it again." Along with all the other ways she helped herself teach this way, this lack of concern about her own performance seemed important for using an approach to teaching mathematics that involved trial-and-error, and risks.

Molly's love of teaching and her immersion in thinking about students and teaching was illustrated well by her comment: "I hope it's reflected in my style that I like kids, that I have fun with them and I enjoy doing the things that I do, so what was your question?"

A Normative Look at Molly's Teaching

Given the concerns of reformers regarding the superficial adoption of reforms, I end each case by reviewing the degree to which the teaching I observed might be thought of as reform-oriented. In doing this, I try to view these teachers' practice through the lens of the mathematics reforms, rather than through their own beliefs. Of course, there are different interpretations of the reforms themselves, and there is no one correct way to do reform-oriented teaching, so evaluations other than the one that I give here are possible.

Of the three teachers, Molly's practice was the closest to the vision of teaching in the reforms, and it was consistent with the reforms in a number of ways. Her practice focused on the development of students' problem-solving abilities, their ability to reason and communicate about mathematics, and their knowledge of the language of mathematics. Molly consistently involved students in learning about mathematics while working alone and in groups, and while using tools such as manipulatives and calculators. She helped students look for patterns in mathematics, and provided opportunities for discovery and for learning from others. Molly actively helped students move away from the view many had acquired--that there is one answer to all math problems and one right way to solve them. Her mathematics practice involved extensive use of literature involving mathematics, and she engaged students frequently in writing and talking about mathematics. She connected mathematics to real-world situations, and connected the contexts of problems to real life. Molly respected the understandings students had constructed, and the answers they gave, but also steered them towards learning the conventions of mathematics. She did not act as the sole authority for mathematical truth, but allowed students to engage in discussing what was true, and had them explain their reasons for disagreeing. Discovery had a place in her practice, as did telling. Over time, students were becoming increasingly self-regulated in their ability to do mathematics, and developed a very positive disposition towards mathematics. The latter seemed to be a significant accomplishment, as many students came to Molly's third grade class already hating mathematics.

Nevertheless, there were significant ways in which what I observed in Molly's teaching was not fully reform-oriented. Most significantly, she and students didn't engage in extended unpacking of mathematical ideas, such as posing and testing conjectures regarding mathematics and discussing the meaning of mathematical ideas or their representations. Perhaps she did some of this in the "math lab" activities, which I never observed. However, in the activities I did observe, students generally didn't get beyond first-level explanations of the "whys" of mathematics. Students' explanations when in the front of the class usually seemed to be at the level of instrumental understanding--explaining what they did, and the steps involved. Molly was worried about losing students' attention and interest. However, occasionally having students get a bit more "bogged down," and slog through deeper exploration of mathematical ideas would have made the teaching I observe closer to the intent of the reforms. Molly may have been moving in the direction of deeper attention to students' understandings, through her increasing use of rubrics for assessing students' explanations of their problem solving. Related to the first point above, Molly's practice could also have been more reform-oriented if she allowed students to take a more active role in shaping the direction that lessons took.

Chapter Three

THE CASE OF PEGGY TURNER

Peggy Turner, Torn between Traditional and Reformed Teaching

Watching Peggy Turner's Mathematics Teaching

The first time I observed Peggy, she wrote 9, 6, 8, and 3 on the overhead, and asked students which number didn't belong. One student said three didn't belong, because it was the smallest. Another student chose six, because it was in the middle, and another said eight, because it didn't have "a point sticking out--an unfinished circle." Peggy responded positively to these replies: "I like listening to what you think." She had encountered this math problem in a county math workshop about reform-oriented mathematics teaching.

A math lesson I observed a few years later was very different. Students worked independently on a series of problems from the traditional, computation-oriented EXCEL program. At this time, Peggy seemed to be using the EXCEL program almost every day.

Peggy's alternating use of both reform-oriented and traditional teaching reflected one of her most worrisome dilemmas:

> How do you make it so that your classroom activities [are] consistent with the framework while at the same time being fair to the child and preparing them for the next grade level and making sure that they have the basic skills that they need? It's kind of tricky, I think it's hard.

Teaching mathematics was especially challenging for Peggy, who said math was "beyond me when I was growing up," that she was "very weak in math in high school--in college, very poor in math, never understood it, just didn't get it."

To complicate matters, Peggy received conflicting messages from her educational and professional experiences. Her teacher preparation program stressed reform-oriented teaching, and theorists like Piaget. When she began her career at Columbus School (with its very-low test scores), school and district administrators emphasized basic skills and content coverage, not understanding. While there, she participated in a master's program focused on the "DISTAR" direct instruction program, which emphasizes procedural mathematical skill, especially for low-ability students. After three years, she moved to Timberside School. There, the principal favored reform-oriented practices, and arranged for Peggy to attend workshops on reform-oriented mathematics teaching. At Timberside, Peggy shared one classroom wall with the reform-minded Molly, and another wall with Beth Schmidt, who used the computation-oriented EXCEL program almost exclusively.

Peggy was literally and figuratively "caught between" traditional and reform-oriented teaching. Her predicament was apparent to me when her room was quiet--you could hear the action from Molly's and Beth's classrooms simultaneously!

With her negative personal experiences in mathematics, and this mix of influences, what did Peggy's teaching practice look like, and what happened when she tried teaching in the more ambitious ways suggested by the reforms?

Making a Few Numbers with Base Ten Blocks

Reviewing the last chapter test, Peggy told the class, "Heads down all around. People are forgetting that there is something called place value." She said they would do the next activity "for practice, and just kind of for fun, in a way. Heads down all around, heads down." In a process that took almost five minutes, she asked a student from one table to pass out the bags of base ten blocks to his table, and then repeated the directions, one table at a time.

Peggy asked students to count and record the number of flats, longs, and ones in their bags. After most students did this, she said "OK, put your pencils down, eyes on me please, points for table number two, good job." Peggy, said she was thinking of a problem:

> Using fourteen pieces, make the number--wait, wait, I'm thinking, OK, just a second, I'm thinking of this number--using thirteen pieces, make the number using thirteen pieces--no, wait a minute, wait a minute, why do I keep saying that? Oh right, using thirt--using fourteen pieces, long, short, everything, using fourteen pieces, show the number fifty.

Students replied "What, huh?" Peggy said, "Using fourteen pieces, either tens, ones, or whatever, make the number, show me the number fifty." One student replied: "That would be kind of hard, if you don't have twenty ones." Many students said they did have twenty ones. Peggy repeated: "OK, using fourteen pieces, show me the number fifty." Some students quickly raised their hands. As students worked, Peggy said several people had it correct, and repeated the problem again. Then she asked: "How many of you would rather if I just have me just say it if you've got it or not?" Peggy went around and let students know if they had the right answer. A few students seemed excited to have it right.

She announced a new problem--show one hundred and ten using two pieces. "Oh that's easy," several students said. The noise level went up a lot, and Peggy asked them to raise their hand if they had it. She walked around, looking at students' solutions. Then she asked the whole class what they had. The first student said "One flat and one ten," and Peggy replied "Right." A student asked, "Why do you call them flats?" Peggy replied "We've always called them that."

Then she asked them to do an "easy" problem--"show me twenty three in as many different ways as you can." Some students raised their hands quickly. Peggy walked around and said to students: "That's one way, show me another." One boy exclaimed that there was only one way to do it (in fact, there were two ways, given the blocks they had). The noise level was rising, but Peggy eventually quieted the class down. She announced: "My question for tomorrow will be [writing it on the board as she spoke] Show me the number 112 as many different ways as you can using your base ten blocks." Then she told the class to put away their blocks and paper, and take out their "Stuart Little" books. During this fairly noisy transition, she gave table one five table points for being the first to get quiet.

During this activity, the class spent ten minutes passing out and counting the blocks, twelve minutes working three problems and waiting for feedback, and one minute cleaning up the blocks.

Peggy's beliefs about motivation. Peggy's use of manipulatives in this activity reflected her belief that students liked to work or play with them. More significantly, this activity was consistent with Peggy's beliefs about student learning.

Peggy's beliefs about learning. As noted earlier, Peggy did poorly in mathematics, saying, "I'd rather forget" her high school mathematics. She remembered math as "who can get finished first, who could get them all correct" and how it was "beyond me when I was growing up, and no one ever addressed it."

If Peggy missed out on the traditional skills of mathematics, why wasn't she focused on those, rather than playing with blocks and different ways to represent numbers? Peggy explained how part of the purpose of the reforms was to "empower more people with the thinking behind math." Referring to staff workshops Molly did, Peggy explained how this applied to students:

> Kids need to know the process, because if they don't know how they arrived at a number, they cannot generalize from that local situation to the whole universe of problems that need to be solved. But if they know why and they understand that they've really made it their own, they can explain why to another person or to the class. They're more likely to stick that in their pocket and use it the next time they have a similar problem but they're not going to do that if all they know is how to do seventy-four times four.

Peggy also thought developing number sense, not computation, was the foundation for students' learning on mathematics:

> Somehow I think that if you have this broad framework, it's kind of like a skeleton. You can hang things on it; then you can hang all those computational methods on it but you need that framework in place first. I don't know.

In turn, Peggy thought using manipulatives was necessary for developing an understanding of mathematics, which fit with an experience she had at a citywide mathematics conference:

> I think from going through that workshop and actually putting my hands on to the rainbow cubes, I began to develop a greater understanding of multiplication. And I think when I came back to the classroom, when we started talking again about arrays, I just had a different way of explaining it.

Developing this understanding was an accomplishment, as Peggy noted "I was in my thirties before I figured out multiplication." The workshop experience made Peggy "appreciate more how manipulatives could be used," so she ordered the rainbow cubes, using money from a parent fund-raiser.

The learning process Peggy outlined had two stages, with concrete activity first, for understanding. Once understanding had been established with manipulatives, "then they can take that understanding to a more symbolic level." This seemed to reflect a belief that students somehow took their own understanding to a more symbolic level. It wasn't clear what role Peggy believed she played in this process, and she didn't do much explicit "connecting" during this lesson. There was no indication of a "bridging" or "connecting" stage from the concrete to abstract, as some commercial approaches suggest. Perhaps she felt she could take for granted that students knew the flats stood for one hundred, etc.

Although she believed that manipulatives helped only when "they're used consistently over a long period of time," she sometimes moved students too quickly from the manipulatives to the symbolic, because the manipulatives got "chaotic." She implied this tendency on her part might have created problems for students' learning. There was some lack of consistency here between what she believed was best for learning, and what she did in practice.

Peggy frequently complained about how noisy manipulatives were, which gave her some reason not to use them. She was very sensitive about noise level in her room because she had received a lot of negative feedback about it in her first year at Timberside. This problem was amplified because of the loft arrangement.

Puzzles. A few puzzles remain. First, was there anything else to Peggy's beliefs about motivation, in addition to students' enjoyment of manipulatives? Second, did she believe that by simply touching manipulatives, students would gain understanding? Finally, besides initiating the activity, did she see any role for the teacher? We turn to another example, to extend our understanding of her teaching, and her beliefs about student motivation and learning.

How Many Cans Do We Each Need to Feed the Needy?

The opening. One morning, a student from an upper-grade class challenged Peggy's students to bring in one hundred cans for the needy. Students got very noisy in response to this. Then Peggy praised one girl for quietly watching the student who had issued the challenge, and told the others to be quiet and "think about this."

She asked the class how many cans of food each of them would have to bring, to come up with one hundred cans of food for the needy. She said, "For one bonus ticket that's worth two [tickets], sometime during today write down what you think." Then she wrote on the board "Need 100 cans," and "There are 30 students and 2 teachers," and "How many would each person have to bring?" Then she repeated the question, and said they could figure it out sometime today: "Accept it as a challenge."

Then she announced that they would start doing a practice timed multiplication test each day "to help us kind of get caught up," and then "have the real thing on Friday." She said this would "help you a lot," and suggested that students who finished the next activity early should work on their multiplication facts.

After quiet reading, Peggy passed out bags of unifix cubes, and had "everybody touch their plastic bags." A second later, she had them take their hands off of them, then she asked them to touch them again without making noise. After five seconds, she told them to take their hands off their bags of cubes, then told them to touch their plastic bags with two hands, but with no noise. Then she told them to fold their hands in their laps, and said they would use the cubes today, but she wanted them to be quiet, and not to touch the bags of cubes for awhile.

Peggy referred the class to a question on the board "How many cubes might have helped in solving the problem?" Then she said she didn't like that question so much because "What we care about in math is not what the answer is, but how you get it, right?" At this point, some students were playing with their unifix cubes, so Peggy said she would give them a gift--they could touch the cubes for ten seconds. Some students started to play with the cubes right away, but Peggy told them to stop, because she hadn't said "start" yet. After one more false start, she signaled start, and the students played with the Unifix cubes very loudly for ten seconds. Peggy told the students that they had gotten their time to play loudly with the cubes, so she did not expect them to touch the cubes any more at this time. Several reminders were given to for students who continued to touch their cubes.

Peggy asked students "How could we use our blocks, not just the blocks in your bag, but all the blocks in this room, right now, to figure out how many cans of food each person would have to bring in order to equal one hundred?" She told them to "put on your thinking caps, get really quiet." This was a better problem, she said, than the one she planned to do: "Cause this is real, people really are hungry, and a hundred cans of food would go a long way to help a lot of needy folks."

She wrote on the board "How can we figure out how many cans each person would have to bring to equal 100?" She asked how they could use their blocks to answer that question. As it got noisier again, Peggy told them to put their heads down and think about how many cans each person would have to bring to have one hundred cans.

Doing the activity. Peggy said, "I'm actually looking for some math Einsteins, some good problem solvers." She asked "How can we use our blocks to figure out how many cans each person would have to bring to equal one hundred?" At this point, thirteen minutes had passed since Peggy passed out the blocks. She asked the students to use paper to write and draw out their plan for answering the question. She told them to work by themselves first and then with their table groups. She repeated the instructions, emphasizing "You don't want the answer, you want a plan."

One student told Peggy how many cans he thought each person needed to bring. Peggy said she didn't care how many cans, she cared about a plan to figure it out. She repeated this emphasis on "a plan, not the answer" to other students.

After students worked on their plans for a few minutes, Peggy clapped her hands and asked whether they wanted to work with one other person or with their table group. She helped them form groups, and suggested that groups could combine all their individual sets of blocks into one large set of blocks. When a few groups immediately started to do this, she said "Not yet!" Peggy said they had about ten minutes, told them they needed to have a written plan, with writing and pictures. She passed out large pieces of paper for groups to put their ideas on.

Each student had only twenty unifix cubes, and with most groups having only three or four students, most groups didn't have 100 cubes. I wondered how the cubes would help the students solve the problem. Some students connected the blocks in long segments, and some students talked a lot about the problem, but some had blank papers. Some students appeared to be simply guessing--one group wrote, "They either need 6 blocks or 27 blocks." Another group drew squares next to numbers that represented people--showing thirty-three people each bringing three cans, with the last person bringing four.

Peggy ended the small-group work twenty-five minutes later. By this time, many students were talking about things other than the problem. She called them to the "circle area" (an open area in the front of the room).

Sharing time. When all the students were seated, Peggy handed out "Buddy Awards," saying they were for students who worked really well together during the activity.

She asked groups to share, but didn't want them to tell their answer. One pair said that each person would need to bring in eighteen cans. Peggy asked how they arrived at this number. They explained and she nodded. She said it was an "interesting idea." Her tone suggested that their answer wasn't correct. She told them to sit down and figure out how many cans that would add up to. The next group's plan was that each of five people brings twenty cans. Peggy said this was "an interesting idea," but pointed out it used only part of the class. Another group suggested they should all bring in two cans because we can count by two. They didn't know how many cans that would add up to, so Peggy asked them to sit down and figure that out. One girl said that if thirty-three people brought three cans each, that would be ninety-nine, so one person had to bring four. Peggy said to the class in an excited tone--"Wait a second, this is something I think we should listen to," and asked the girl to repeat her group's answer.

At this point, many students were still working on the problem, and weren't paying attention to those who were sharing. The noise level was such that it was difficult to hear, even for those who were trying to pay attention. Perhaps this noise wasn't unexpected, since Peggy told some groups to sit down and do the math to figure out what resulted from the answer they had shared. As other groups shared, Peggy asked how they used their blocks to solve the problem. However, most groups seemed to have worked from their drawings, not the blocks. Some of the drawings were very confusing as schematics of solutions. The group got restless as the sharing time reached fifteen minutes, but then recess time came.

More groups shared after recess, including a group who said they were counting by tens, but didn't know why. Peggy concluded the activity by saying how math was all around us, and how when we are doing something that involves mathematics, there are so many ways to do it.

Peggy's beliefs about motivation. This teaching example reflects Peggy's belief that it was important to decrease students' concerns about giving the wrong answer:

> It's very harmful, because they're being held back from, you know, they're not moving forward as I think they should be because they don't want to say anything because they don't have the right answer. I know I have lot fewer kids crying.

Peggy cared about correctness, but didn't want to squash students' motivation: "I say 'That's interesting'-- knowing in my heart that it's totally wrong, but I don't want to discourage them, you know." For Peggy, errors were something to feel bad about or be discouraged by, and I wondered if this concern related to her own negative experiences in mathematics. Reflecting on this activity, she said that half of the students probably didn't get it, and many of their answers "didn't really make a whole lot of sense," but she didn't want to say they were wrong because she felt it would undermine their thought process. She hoped that all students could experience the accomplishment of turning in plans even if they didn't get the right answer "so people don't feel bad if they don't come up with an answer."

On the other hand, Peggy believed students got excited when they discovered the correct answer. This left her with a tricky path to walk--allowing for the excitement of correct answers, but not stressing them so much that those who got it wrong felt discouraged. Perhaps Peggy didn't correct students publicly in order to avoid dampening their spirits. Instead, she asked them to re-work problems alone, to allow for the potential excitement of finding the right answer. However, I thought her tone gave students the message that their answer was wrong. It wasn't clear that those students knew how to figure out the answer when they were sent back to work on it again. Also, Peggy seldom gave help or much support for figuring out the correct answer.

Her beliefs about motivation were also revealed in her comment that she was looking for "math Einsteins" and "good problem-solvers." Peggy spoke of ability as something students had, rather than something they acquired, and she believed ability mattered for motivation. In contrast to gifted students, she thought the students she typically had acted out because "They don't have a clue and they don't really want to find out." She seemed to believe that not all students are inherently curious, or intrinsically motivated to learn.

Extrinsic rewards were a significant aspect of Peggy's teaching practice. During this observation, she used extra minutes of recess, tickets that could be traded for candy, praise, and the "Good Buddy" awards to motivate students. She acknowledged that she relied on rewards quite a bit: "If something isn't working, I'll offer a bribe. 'If you do this, I'll do this.'" Peggy believed rewards had some role in teaching, but she had mixed feelings about using them:

> Well, you know you can't really have instruction unless the tone is set, and you know, so what are you going to do? And I find that, as a somewhat inexperienced teacher, I tend to rely too much on bonuses like "I'll give you this if you do this."

Though it was difficult, she said she was "gradually weaning myself" from this practice, because she recognized that rewards created problems: "You don't need to bribe kids. But once you start the bribing, you kind of have to keep it up. You have to continue it because they expect it." For example, she said that when she asked students to do something, a typical reply was "what are you gonna' give me?"

In spite of her belief that rewards were unnecessary, she didn't know how she would motivate students without them: "So, I've gotten better but I'm still, like, too hung up on constant feeling that I can't get anything out of kids unless I reward them." She said this feeling was due to her "insecurity that I had the ability to really get kids to do what I needed to have done." In the last interview of the study, in her eighth year of teaching, she still admitted insecurity about "my ability to motivate them and to hold their attention and to, to, just to get them to do what I wanted done. So it's always been, to me, kind of like that secret corner of fear that I have."

Based on this observation, I wondered if Peggy had sufficient training to use an applied behavioral approach to classroom management successfully. Although she used rewards and punishments liberally, she didn't use them in ways most likely to yield behavioral control (e.g., Alberto & Troutman, 1995). For example, in the case of the good buddy awards, she didn't tell students in advance exactly what behaviors would be rewarded. In addition, it wasn't clear that children valued the good buddy award, and so it may not have reinforced cooperative behavior, even if Peggy had clearly established what they had to do to get one.

It is also possible that some behavior problems were due to the way Peggy handled the logistics of this activity. For example, the cubes were passed out before she wanted students to use them, and she gave instructions in such a way that students started before she wanted them to.

Finally, perhaps Peggy struggled during the opening of this activity because she wasn't heeding her own beliefs about motivation. Despite believing that students liked to get their hands on manipulatives and move them around, she handed out the cubes and then expected students to keep their hands off of them! She may have made the cubes even more appealing by forbidding students to touch them.

Peggy's beliefs about learning. Peggy had her own epiphany of mathematical understanding while doing problem solving in a research course in her graduate program in sociology:

> All of a sudden I understood it and I was really angry because how come I didn't get this before? I mean, it was math, but it was applications I guess, and I really, I got so much out of it, I got real excited about problem solving and understanding different parts of the statistical puzzle and that kind of thing, and for me, that is really math. But I was real excited and I got really angry that, why wasn't I doing this before?

This experience may explain why Peggy emphasized problem solving in her teaching. Peggy believed that solving problems developed students' number sense. However, doing problems such as the one in this example required number sense: "when kids have a problem to work on and they're completely baffled by it I think they just don't have a very good number sense." Thus, in this activity Peggy might logically have believed that the students' struggles reflected lack of number sense, and they simply needed to do more of this kind of problem. Another belief would be that with more support or modeling, students might have solved this problem easily. Why didn't Peggy model strategies for solving this problem? Was it because she didn't know such strategies, didn't know how to teach them, or didn't believe in teaching them? It wasn't clear what the teacher's role was in facilitating problem solving.

Discovery was an important part of learning by doing for Peggy:

> [If] you really want to encourage the whyness of why something is, why two plus two is four, you really need to give them an opportunity to figure them out on their own. You can tell them over and over again that two plus two equals four because and tell them exactly why, but they won't really own it until they figure it out for themselves.

She believed that using manipulatives such as the unifix cubes helped students learn by a process by "discovering it on their own at their own pace." She believed that a lot of learning wouldn't happen right away and "they may not even get it when they're with me, but maybe they'll get it another way at another time if they have the opportunity to use the [manipulatives] again."

The theme of "doing it on their own, figuring things out for themselves" was prominent when Peggy spoke about learning. Consistent with this theme, in this activity, students were very much on their own in figuring out the problem. Perhaps Peggy's belief in discovery "on your own" is one reason why she didn't model problem-solving strategies.

Peggy also believed that the noisiness and activity level that I saw here with the manipulatives was important for learning, in spite of her complaints about the noise:

> They need those moments of chaos and madness and movement and what looks really crazy to us may, or it may in fact be part of the process of their learning so I try not to shut it down too much with a lot of "shhh."

She acknowledged that during such chaotic activity, some students didn't do what they were supposed to, but she believed that even if she had them all controlled and sitting still for direct instruction, some students might be tuning her out then too. It sometimes seemed to me from her comments as if she believed direct instruction or somewhat chaotic discovery were her two teaching options.

Peggy believed that focusing on the process rather than correct answers was important during discovery. However, this activity was an interesting example of apparent discrepancy between her beliefs and practices. Peggy strongly and repeatedly stated that she was most interested in the students' explanations of their thinking, or in the "cans for the needy" activity here, their plan. She tried to de-emphasize the answer, believing that "this class tends to focus in on the number, the answer. They'll just write one letter and say okay, well that's my answer." In this example, however, most of what students shared were answers, not reasons. Furthermore, she gave more positive attention here to the students with the correct answer, as she did on other occasions. For Peggy, perhaps knowing how to solve the problem reflected understanding. In interviews, she clearly stressed the "why" aspect of students' understanding of mathematics. Another possibility is that Peggy had heard reform rhetoric about student reasoning and discussions in mathematics, but hadn't been taught how to engage students in such discussions.

Puzzles. This example raises additional puzzles about Peggy's teaching. First, with her concrete-to-abstract beliefs about learning, why did she ask students to provide a "plan" for solving this, without doing the problem? She seemed to be asking for the abstraction first. Second, as most groups did not have one hundred cubes, how did she expect them to use the cubes to solve the problem? Third, she reported that half of the students didn't "get it" during this problem. She noted her own lack of expertise at discovery learning, but said that she might do some modeling next: "To try to get them kind of towards where it is we're trying to go." Did she believe in modeling strategies only after students struggled, or had she concluded that students might need more help from her to be successful? Fourth, she told me that they would not finish this problem until eight days later. I thought these students could easily grasp this problem in a lesson. Was she trying to stretch a problem over several days because that's what the reforms said "good problem solving" was, or didn't she believe they could master this problem faster?

We're left with a number of questions, and turn next to a similar example of her practice, partly to better understand the role of discovery in her teaching.

Of Elephants and Kings

The problem of the elephants and kings came from a story Peggy read to the class. She asked the students to draw pictures and write a plan for how seventeen kings could take care of forty-two elephants in a fair way. After repeating the task several times and passing out papers and pencils, they got started.

Peggy soon announced that if they wanted to, students could use calculators to figure out the problem. Then she seemed to reconsider this, saying that maybe they could think of a plan that did not require them to use a calculator. One boy plugged "forty-two divided by seventeen" into his calculator, saying it out loud as he did it. Meanwhile, Peggy asked students what they thought they should do to figure out this problem. Students who had drawn circles for kings and lines for elephants (or something similar) seemed confused about what to do with the arrays they created. Even many of those who started off promisingly got stuck after distributing one elephant to each king, in part because they were drawing lines across their papers from all the elephants to all the kings, and it was difficult to make the connections clearly.

Thirty-five minutes after starting this problem, the first student finished, and started working on her EXCEL worksheet. One student solved the problem by having kings "take turns," another gave three elephants to eight kings and two elephants to nine kings, others gave each king two elephants to care for, but had leftover elephants. Another fifteen minutes later, all the students had finished the elephants and kings, and were quietly working on EXCEL worksheets. Ten minutes later, Peggy asked them to put their math away and to go to circle.

At the circle, over the low rumble of student activity and voices, Peggy gave an extra minute of recess to a student for being "another great sitter," but other students didn't seem settle down any. Peggy explained that there are two kinds of math--the EXCEL kind, and the kind which had nothing to do with the big long (EXCEL) sheets, such as the elephants problem. Most students agreed that there were these two types of math. Peggy asked them to vote for which kind they liked best. Nine voted for the problem-solving kind, nine voted for EXCEL, and six voted for not liking either one. After the voting, they began discussing their eating preferences. There was no discussion of the problem of the elephants and kings, or the EXCEL worksheets that they had just completed.

Peggy's beliefs about motivation. Peggy noted that her students hadn't responded as enthusiastically to problem solving this year as in previous years, and said this lack of enthusiasm often made them hard to work with. She believed that they weren't as enthusiastic because she hadn't done as much of it, and it took time "to build it in." Interestingly, she thought she hadn't done as much of it because students hadn't responded enthusiastically when she first did it. I wondered if students' lukewarm reactions to problem solving were due in part to negative experiences they'd had with it. This example of the elephants and kings is a case in point. The difficulty students had in modeling this problem, and the lack of discussion about it made success difficult, and frustration likely. Would students' liking of and motivation to engage in problems like the elephants and kings problem have been higher if Peggy provided more "scaffolding" for their learning, such as helping them learn problem-solving strategies?

Peggy's beliefs about learning. A workshop by Constance Kamii had apparently influenced Peggy's thinking about discovery learning. Kamii discussed a study in which students who had discovered their own methods of computation had done better in fifth grade than students who were taught traditionally. Peggy felt nervous about what would happen if she followed the discovery approach and students moved to another school. However, she basically agreed with Molly "that you don't really need to focus so much on computation, that comes with time, once they have the understanding." To support this claim, Peggy noted that she "never taught long division yet most of my students can do it." As with the cans for the needy example, belief in the effectiveness of discovery-- without teaching-- seemed to be the foundation of the elephants and kings activity.

Peggy believed discovery had drawbacks: "There are times when discovery learning, frankly gets in the way. It slows things down." She thought discovery learning had a place in the classroom, "but at the same time, we're in the real world. These are third graders and they need to, we need to cover with them or expose them to a certain amount of material." These concerns may have reflected her lack of understanding of how to guide students during "discovery." I asked how she knew what to do with students in such activities:

> That's kind of the problem I think. Because you know, I still consider myself a novice in terms of discovery type learning because I think cause it takes a really skillful teacher to do it well but I don't have time for them to arrive there whenever they get there.

In Peggy's classroom, discovery did take a long time, and her only role seemed to be one of waiting to see if students "got there." Even her goal for the elephants and kings activity sounded passive: "I was hoping that they would discover that there was a remainder and that they would have to think of a creative way to dispose of the remainder."

Ending puzzles. Peggy said she would do this lesson again, but do it completely differently. She described having students work with partners using privacy boards, getting them to "really focus in on what they're doing without a calculator," and finally "to see what they come up with." It wasn't clear that Peggy had a vision of what she wanted them to learn from such activity, and how she could help them learn.

EXCEL: Traditional Content in Worksheet Form

At the end of year three of the study, Peggy began mathematics one day by having students work on nine problems from the guided practice section of EXCEL lesson #105. She told them that if they needed help, she would work with them, or she could assign another student to help them. She told them that as long as they used "a six-inch voice," it was OK for them to work with a partner, because other students "sometimes they can explain things in ways that older people or teachers cannot."

The EXCEL program is a series of worksheets with quite traditional mathematics problems. The first page of the computation-oriented EXCEL program suggested that the program worked well for traditional measures of mathematics ability: "This program over the last few years has been tested against other comparable programs. The results based on standardized tests have consistently shown this program to be superior." The lesson and homework appear on one side of the oversized worksheets, with guided practice problems on the other side. Each side of a worksheet is divided into small boxes--with two or more questions per box. In the homework and guided practice portions, the sum for the answers for the problems in each box is given in a corner of the box. This is a self-correcting mechanism.

My interactions with students during this EXCEL lesson were revealing. One girl asked me how many ounces were in a pound. I said sixteen. So on a problem that said 3 pounds = ______ ounces, the girl wrote 16 in the blank. I said to her "there are sixteen ounces in one pound, so how many are there in three pounds?" She then added 16, 8, and 3 vertically on her paper, and wrote the sum of these as 58. Fifty-eight was the sum given for the answers for the two problems in that box, and despite my comment, she had written 16, not 48 (for 3 pounds) and then the numbers she thought were the answers for the other two problems. One of these was right, the other wrong, and they didn't add up to fifty-eight. Then her partner said "It's 48" and she happily wrote that down and went on.

Another boy had calculated wrong answers for both problems in one box, but had arrived at the right total sum. I observed another boy who had written $4.21 - 2.89 = $1.72. Here, $1.72 seemed to be what made the sum come out right for the box of problems, given the answer he already had. This boy and a second boy explained to me that you could check to see if you had it right by adding the numbers, and their sum should equal the number in the box. I asked if you could have the right sum, but have the wrong answers to the two individual problems. The second boy said yes--if you had the answers switched. Apparently, no other possibility occurred to him. Then the first boy, who had folded his paper, opened it up again. I believe he took my comment as a hint that he may have gotten something wrong. He added up his two answers again, which equaled the number in the box. Although both of his answers were wrong, he seemed satisfied he had done it correctly, and began to talk to me about sports.

Peggy said, "If you are in need of help, check with your neighbors first." As the work continued, Peggy continued to help individuals, and the low rumble of off-task talk continued. As she asked students to go back to their seats and quiet down, Peggy penalized a few table groups one minute of recess for being noisy. She said how she was glad that so many students had someone next to them who could help them: "Sometimes when we talk about a problem, we are more likely to figure it out, than if you try to sit and struggle on your own."

Moving on, Peggy told the class she was convinced there was always more than one way to solve a problem, and modeled three different ways to calculate 9387 x 4. She suggested that they could use these strategies on the EXCEL problems they were doing.

During this, many students weren't tuned in to her modeling. Some were already working on additional EXCEL problems she had assigned, and many were engaged in off-task behavior, such as the boys near me who were talking about their dogs.

Peggy's beliefs about motivation. Peggy believed students liked doing the EXCEL problems, because the difficulty level was such that they could do most problems successfully. In addition, she believed that the self-correcting mechanism allowed students to check their answers right away, so they could experience success without waiting for a teacher. However, as I noted in my observation, many students were getting a misplaced sense of satisfaction from this self-checking mechanism. Some came up with two incorrect answers, which satisfied the "self-checking" sum. Also, some students worked the first problem, then did subtraction to get the answer for the second problem, without ever working it through.

Another motivational issue had to do with the type of mathematics different students liked to do. Peggy said some students still wanted to get that right answer, and especially in this year, "a lot of them really prefer to sit and do EXCEL math than to do anything that might require some more critical thinking." Peggy said some of them would do all of the EXCEL problems even though they weren't all assigned.

As noted in other teaching examples, while Peggy often used the "carrot" of rewards to motivate, but when students did get "crazy," she often pulled out the "stick" of punishment--typically taking away minutes of recess from individuals or entire table groups, as she did here. The tally for gained and lost minutes of recess for individuals, tables, and the whole class was updated throughout the day on the board.

Competition was another extrinsic factor in motivation related to this math lesson. Peggy believed students did these worksheets partly as a contest--racing to finish first. Peggy doubted that being motivated to race through the math had a positive long-term impact--"I don't think that helps to make math very exciting or a life-long pursuit."

Peggy's beliefs about learning. Peggy believed that teaching only in a traditional way, or only in a reform-oriented way could create gaps in students' learning. Noting that her older daughter "grew up with enormous gaps in her learning," she explained how this affected her mathematics teaching:

> Maybe that's why I hang onto EXCEL even though I keep saying I'm not going to because I'm thinking well, you know, if they miss this when will they get another chance to learn it? You know and--I guess that's why I'm more eclectic in my approach to the whole thing.

Peggy believed the mixed practice in the EXCEL program was effective. The homework and guided practice problems always had various types of problems--addition, multiplication, writing numerals, geometry, division, etc. Peggy believed this feature worked "because it allows for very frequent practice of the concepts." She said the hope was that "through exposure, and constant reinforcement after the lesson, that they're going to catch it."

However, Peggy believed using a program like EXCEL exclusively contributed to gaps in learning. She noted that the students' practice of racing through problems meant some didn't quite get it--they just put down something. From my observations, I concluded that this was the case.

This teaching example also illustrates her belief in the role of peer-peer interaction in learning. She encouraged students to work together and help each other. She said that students might not understand something when a teacher explains it and won't "understand it until their peer explains it to them."

Peggy's own motivations. This observation also sheds light on the factors that motivated Peggy to use traditional practices: "If it appears simple, I'm motivated to use it. If it is really easy to use, I'm motivated." She said EXCEL was easier to use and more expedient. Reform-oriented practices were more difficult and she sometimes just did what was expedient.

External pressures also motivated Peggy. Three months before this observation, Peggy was doing more reform-oriented teaching, citing the Constance Kamii workshop she had attended. She was confidently proclaiming that if she was behind on lessons covered, that was OK, because her students simply may not have been ready to do the same lesson as students in other classes. At that time, she estimated she was using EXCEL only one-third of the time.

Three months later, things had changed. Peggy estimated that she had increased her use of EXCEL to two-thirds of her practice by that observation. She noted the reason for the change: "Parents made comments that I was not on the same lesson as Beth. Two parents, one went to Debbie (the principal) to complain." Peggy felt that this pressure on her was "dumb," but it impacted her practice nonetheless: "I just started skipping lessons and rushing through the stuff. If that's what they want, I mean, that's what I did."

Peggy had spoken earlier about the "turmoil" she felt in choosing between the traditional and reformed approaches. However, her increased use of EXCEL at this point didn't seem to reflect her professed beliefs about what worked best for students: "I'm much more sure about what I think should be done, but I don't always do it. And I suppose that's the only inner-turmoil that I go through, is that I know, but I don't always do it." This change in practice without an accompanying change in beliefs demonstrated the lack of connection between Peggy's theory and her practice.

I turn now to explore further the main themes in Peggy's beliefs and practices.

Main Themes in Peggy's Beliefs and Practices

Themes in Motivation

Consistent with her overarching goal "to develop a love of learning" in all students, Peggy hoped she would help students "have fun with" math, and have "that love and that interest" for mathematics.

She noted a few factors related to students' liking of math, some of which I thought were related to motivation, but I made these connections, since Peggy didn't make them explicit.

Peggy talked more clearly about problems of motivation than she did about how students were motivated, and talked less about motivation to learn, and more about how to motivate students to behave. Student misbehavior, losing control of the class, and her ability to control the class came up repeatedly throughout the study, and were clearly relevant to her mathematics teaching.

Given the picture above, what do we know about Peggy's beliefs about and approach to student motivation?

Catch 'em being good. When I asked her directly about her beliefs about student motivation, Peggy replied: "I don't know, you can catch more flies with honey than you can with vinegar. So I tend to try to make it more of a positive kind of thing. Most kids like me." Peggy did use something sweet (Jolly Ranchers candy), in addition to extra minutes of recess or the good buddy awards to motivate students. It was "one thing about my own teaching I have never liked," but she felt rewards were necessary when "you really need everyone's focus," such as during direct instruction:

> And if they're not gonna' focus any other way because they're bored or because they don't feel like it and you can capture them, their attention and hold onto it. You get it through the little temptation of the little carrot and then you keep it through your own teaching and instructional style and message that you're presenting. I think, yeah, that it can have a positive impact on instruction.

Peggy's explanation is consistent with an applied behavior analysis approach to instruction (e.g., Alberto & Troutman, 1990), in which a stronger reinforcer is initially used to gain attention and compliance, then faded as other reinforcers inherent in the task take hold to maintain motivation.

Peggy spoke often and more passionately about the pitfalls of motivating students with rewards than about their benefits: "It causes chaos. It causes arguments, fights, ah, frustration on my part when I need to have something done and I don't have a reward. It's just caused a lot of problems in every room I've ever had." Peggy noted that when the reward "becomes the central focus, then it becomes a problem." I observed this during my last observation, as Peggy tossed Goldfish crackers to students to maintain their attention during a question-and-answer session. The students became very interested in playing with and eating the crackers. Critics of using rewards to motivate learning (e.g., Kohn, 1993) note that this is a common problem--students become focused on the rewards, and not on the learning itself.

In sum, Peggy had a handful of applied behavioral techniques for motivating students, but she didn't use them effectively. Performance-reward contingencies were not clear, they were given late or inconsistently, and students did not often value them. Peggy's use of praise seemed too global to be effective (e.g., Gartrell, 1994). She didn't use any of these specific rewards or punishments steadily or consistently, and often didn't follow through on her stated expectations for students.

Peggy spoke of wanting to move away from using extrinsic motivators with students. Yet she had little information on alternatives to guide her. When she imagined stopping use of rewards, she expected problems, and said her approach would be "Just not to weaken. Just to take the stand and stand, and don't weaken even when things get kind of crazy."

Not surprisingly, Peggy spoke of her struggle with classroom management and her inability to maintain student engagement throughout the study.

Different students. Peggy believed that student ability was a key factor in motivation. Simply, she believed gifted students were "more motivated," because "they've met with a lot of successes." She described her more average students as unmotivated to learn. She also felt that "you need some high achievers in your classroom to stimulate the other students and to set up an example." Again, Peggy emphasized the importance of extrinsic factors for impacting student motivation.

Failure and success. Peggy's beliefs about student motivation were clearest when she spoke about the negative effects of failure. As I noted earlier, her own experiences of failure in mathematics may have shaped her conviction that failure undermined motivation. She repeatedly spoke of the dangers of squashing student motivation through failure. Peggy believed she protected students from failure by de-emphasizing correct answers. She felt students were "always being tripped up by the need to find the correct answer," so she tried to be more accepting of wrong answers. Correcting students too much "squelches a lot of creativity and discovery time, really." She believed de-emphasizing right answers also improved engagement: "they're more likely to raise their hand and get up and say something and feel that they're being applauded simply for thinking." Peggy linked use of this practice to the mathematics reforms: "I understand the new math thinking a lot better than I used to, I think."

In addition to protecting students from failure, Peggy wanted to create "a feeling of success in all of my students, and reach as many students as I can." She cited examples of success in EXCEL, with problems that students could do and check, and in the greater motivation of gifted students. Peggy provided opportunities for success by regularly assigning problems and activities in which multiple correct answers were possible. She also did a "number of the day" activity--for example, having students generate as many equations as they could that equaled twenty.

Unfortunately, there seemed to be quite a bit of failure too, as reflected in the incorrect answers on the EXCEL worksheets, and students' struggle with problem solving.

In spite of Peggy's efforts to support success and minimize failure, students and Peggy seemed to have gotten into a negative cycle. Students responded negatively at first to problem solving, and so Peggy did less of it. Students didn't get experience in problem solving, and it became harder for them to succeed with it and like it. Many of them didn't want to do it, and Peggy continued to do less of it.

In the end in Peggy's class, traditional worksheets wound up in a dead heat in student popularity with the problem-solving that is supposed to be so enjoyable and engaging.

Miscellaneous factors. Peggy mentioned a few other factors she believed impacted student motivation, such as playing with manipulatives, being excited about discovering an answer, and enjoying talking with other students.

Lacking a set of beliefs about how students could be intrinsically motivated, and could even love math, Peggy lacked a significant alternative to using extrinsic rewards. This did not seem surprising to me. In my experience, teachers have often learned many "tricks of the trade" for motivating students using rewards and punishments. They usually know little or nothing about intrinsic motivation.

Peggy found herself in a frustrating situation. She wanted students to love mathematics, but she did not have a coherent theory or set of practices to help make that possible.

Undermining motivation? Peggy pointed out two aspects of her practice that she believed might have negatively impacted students' liking of mathematics. First, she tended to focus on the students who "got it," and didn't make adjustments for those who weren't "getting it." Second, she was preaching that math was fun, but wondered if her actions gave students the opposite impression.

There were two other ways in which I felt Peggy undermined motivation. First, her pace of instruction was very slow. For example, the feeding the needy activity took fifty minutes, and groups shared their answers for thirty minutes. In addition, she often spoke in a very slow, deliberate style. My impression was that she did this to get students' attention and to maintain control. The style seemed to have the opposite effect, as many students consistently tuned her out. Second, Peggy didn't consistently present math as interesting. For example, one day she made a frequency chart in the class for the students' "most disliked subject." This seemed to unnecessarily frame subject matter in a negative way for students. Perhaps it reflected Peggy's feelings as well.

Main Themes in Learning

Heading in the right directions. Peggy stressed both traditional and more reform-oriented goals in mathematics. On one hand, she thought state-level people knew "for a fact" that we don't have enough people coming out of school ready to run the world, and that this is more of an emergency than most people realized. For Peggy, the crisis was related to students having rote skill but not understanding: "You have kids who can add two plus two and can subtract twelve minus six but they have no idea when and why and where they're supposed to do that." To prepare students for the twenty-first century, Peggy felt we needed to "empower" them "with the thinking behind math." Therefore, one of her goals was that students understood "addition, subtraction and multiplication, not necessarily division." Peggy hoped students could solve math problems--"like something you might have in science lab," and could handle even "amorphous" types of problems. She hoped they would see the possibilities in math, be creative with it, take risks, try things out and be able to communicate about math. She thought it was "kind of shaky" to only use EXCEL, because she believed it was the variety of things she did with students which helped them understand mathematics.

On the other hand, Peggy emphasized traditional skills. She worried that some students would fall through the cracks, fail to master basic skills, and wouldn't be prepared for the strict expectations of fourth grade. When I asked about her goals for students, she mentioned the doing first--that they "be able to do addition, subtraction and multiplication, not necessarily division."

Noting that there was a "philosophical rift" at Timberside between those who supported EXCEL and those more into "problem-solving type things," Peggy advocated a marriage of the two. She explained how there were "so many commonalties, you know, ways that you can mesh the two together." She used both reformed and traditional in-class activities and traditional homework:

> You know, and maybe that's kind of a contradiction, but the why will be in the discussion, but the homework is usually go ahead and do it. Show me that you know how to do it, you know. 'Cause I think both sides of the coins are important. [It is] more kind of, rote kind of things where they just need to know how to do it.

Peggy's practice was consistent with her two-sided view of mathematics teaching and learning. Sometimes, her lessons centered on computation problems. At other times the lesson focused on a single "problem-solving" problem, although it wasn't clear how the two types of practices were "meshed."

Learning by doing. Peggy believed students learn by doing: "that's one of the best ways for kids to learn and adults too, is you actually get them involved." I explore below the types of doing she valued.

To Peggy, touching manipulatives--the first stage in her two-stage learning theory--was the only way students would understand mathematics. Manipulatives helped her understand mathematics, and teachers who didn't use them were not building the framework of understanding:

> I've visited other classrooms when they were talking about math with regrouping and I know for a fact that if it's a whole-class lesson without manipulatives, the kids aren't gonna' get it. I'm sorry, I just don't believe they will and if they do, it's not gonna' stay.

Another reason she believed using only EXCEL was "kind of shaky" was because it put the cart of mathematical abstraction before the horse of understanding--which was built with manipulatives.

Nevertheless, Peggy often didn't use manipulatives--"we don't have them out a lot." If students started "messing around" with them, she would conclude it wasn't worth it: "I'll do it another way where there are no manipulatives. I'm not seeking any understanding, I'm just trying to get through it." This was another way in which her practice didn't follow her beliefs. However, this is understandable, given her ongoing problems with classroom management, especially when using manipulatives.

Discovery was an important to learning by doing, even for computation:

> I think kids end up computing as well as they want to. If they need to know the exact answer, they'll figure out a way to come up with it. Yeah, I think kids will come up with a way, and I know I'm talking, speaking with forked tongue, but at the same time, I don't know. You know, they will learn to compute when they need to compute. They just will. They'll know. They will know. Not automatically, but they will discover, they will know.

Her "forked tongue" comment seemed to reflect an awareness of a possible contradiction in her beliefs. On the one hand, she said students would discover how to compute. On the other hand, she used EXCEL and traditional homework to teach computation, and believed students learned to compute by doing lots of computation problems.

Discovery involved de-emphasizing correct answers. On problems where there was a correct answer, they would work toward that later on, but Peggy wanted them to "know there is kind of a right, wrong, without being blinded by it." She repeatedly told students she didn't want to know the answer. She said she just wanted to hear their thinking, which was "far more important than getting the right answer." She felt "kind of funny about" letting them give her wrong answers, but believed it was valuable for "getting to what they're really thinking about." At times, the discovery process sounded vague, with progress and learning uncertain: "[I] want to clarify the general direction you might want to move in when solving these kinds of problems and hopefully they would kind of move in that direction when we did the next one." I neither observed her model, nor heard her talk about problem-solving strategies that might aid this process.

Learning from others. Saying "it's real important that kids talk about math," Peggy thought students learned new strategies from each other. She believed that such peer-peer learning, especially between students of different ability levels, was part of the intent of the mathematics frameworks. She said "when they sit and they talk to a neighbor, then they do begin to get a lot more understanding from that." She believed that "some kind of self-talk" and discussion was "part of the process of going from the concrete to the more symbolic."

Peggy may have emphasized the importance of peer-peer interaction in part because she felt students didn't always understand her:

> Some of what I say is not comprehensible, I mean they don't comprehend it. They just don't. They don't know what the heck I'm talking about. They have no idea. I'm tall and my voice goes out that way and doesn't really filter down. They hear it, but it sounds like garble, it probably sounds like, you know, when I'm talking to my dog, all he hears is, "blah, blah, blah, blah."

Learning from peers also resulted in part from the way in which students "sometimes can explain things in ways that older people or teachers cannot." Again, Peggy's faith in peer-peer interaction, and the reduced role of the adult reflected some Piagetian-oriented perspectives on learning (e.g., Kamii, 1990).

Valuable learning from traditional practices. Peggy believed traditional practices helped students learn certain knowledge and skills. She attributed students' perceived good performance on the ASAT math section (the tests hadn't been scored yet) to the traditional math problems she had sent home as homework that year: "It really made a difference. It made a very big difference, because they were able to tackle almost every type of problem because they had been exposed to it all year long." Her beliefs and practices seemed to emphasize that students would really learn computation by doing a lot of it. I also wondered if Peggy knew more about a traditional computation-oriented approach than about a reformed approach. That is, the only time I saw Peggy model multiple solution strategies was for multi-digit multiplication.

Describing the EXCEL approach as "a building block type process," Peggy believed the mixed-practice component of the program contributed to learning and to knowing "how to approach a problem." She believed students needed to know "the format" of EXCEL, since it was used in fourth grade. Learning math another way might not generalize to the EXCEL format: "You might still cover those concepts in your classroom but I don't think a third grader going into fourth grade is going to remember when it's put before them in that format."

If learning was so particular to format, this raised questions about how different forms of teaching and learning could be meshed, but it did help explain Peggy's use of EXCEL.

Different ways of learning for different learners. Peggy didn't believe that the reform-oriented practices worked well for all students.

She didn't "really philosophically agree" with part of it, but wanted to use more of a DISTAR-like approach, with scripted instruction and unison responses, especially for her lower-ability students. Why the temptation? Based on her master's program, Peggy "saw how it worked with kids," and described it as "documented, well researched ways to reach kids that are not performing at expectation levels." She acknowledged this approach would "come in conflict with the frameworks, but thought it was needed with low-ability students: "there are times when you just need to tell them how to do it rather than to help them to understand why. You just need to know how to do it."

Peggy thought Molly did wonderful things in her teaching, but attributed this in part to the students Molly had--"kids that have a lot of confidence in their academic ability, they're just easier to work with." In contrast, she felt her own students were unmotivated to learn, and didn't want to do critical-thinking.

Puzzles. A few puzzles remain regarding Peggy's beliefs about learning. It wasn't clear how Peggy believed concrete activity got "connected" to mathematical terms and symbols: "I don't know how it all comes together." It also wasn't clear what Peggy believed her role was in helping students during discovery or discussions. Finally, how did she believe students meshed the two types of mathematics experiences they had?

Peggy's Motivation and Learning

Peggy's Motivations

Mathematics was not Peggy's first teaching priority. If time was tight, Peggy sometimes dropped math from her plans, partly because of her feelings about it: "If I felt that I was more capable in math, yeah, I think it would make a difference in terms of where I would put it priority-wise." The many simultaneous state-level reforms in California made it hard to make math a priority: "I think as a teacher you have to kind of prioritize this stuff. If your thing happens to be social studies, then you probably look at that framework more seriously." Given her feelings and the multiple reforms she had to contend with, she said mathematics sometimes "gets on the bottom of the stack."

Simplicity of use often motivated Peggy's choice of methods, as reflected in her use of the EXCEL program. Doing what was expedient and less time-intensive made more sense given her life circumstances. Peggy had two teenage daughters, and her years at Timberside were also her toughest years as a parent: "So I tend to come and go. I just come, I put in my time, I do whatever I can in the best way I can, and then I leave."

Peggy's motivation seemed to be significantly shaped by others, and she described herself as "a people pleaser." She once admitted that she had started to pull out the manipulatives because I was coming--I assumed she thought I expected reform-oriented teaching. Also, on the day of the EXCEL lesson, she told me they were doing EXCEL only a couple of days a week. A girl who was in for recess replied "A couple of days? We do it every day." Though Peggy said "No I don't," the student persisted. Later, during the interview, Peggy acknowledged she was using EXCEL 65-70% of the time, and was doing more and more of it. Again, I assumed she thought I expected to see reformed practice, and was self-conscious about using the EXCEL program so much. Of course, she could be pushed some in either direction, as when the two parents complained she wasn't doing enough EXCEL: "I felt some pressure to do more of it, and I did. And I just started doing more, more and more." In reflecting on a difficult year, she noted her own need for stimulation from outside: "One needs to be constantly motivated from someone to stay alert and to stay on top of things. Otherwise, you're going to fall into a rut and your students go right with you."

Peggy seemed concerned about how her teaching compared to and appeared to others. She was very aware of what other teachers were doing in teaching math, and whether she was keeping up in EXCEL with them. She also described how Beth would sometimes do very "showy activities" just to impress parents: "And sometimes, I'll buy into that craziness. Most of the time I won't, but every once in a while this year, I've found myself doing something because I knew it would impress my parents at open house."

Peggy also said she was motivated to use reform-oriented practices by seeing other teachers using them successfully, although she never gave a specific example of this for mathematics.

Peggy's Learning

After eight years of teaching, Peggy said, "I still feel like such a novice," and "I'm still learning. I'm still just trying to catch on to what is this thing we call teaching."

In mathematics, Peggy had learned from hands-on manipulation of rainbow cubes in one workshop, and from actively doing and discussing mathematics in the county mathematics workshops. She seemed fascinated and quite surprised by how involved teachers got in discussing a number problem like the one in the opening example--3,6,8,9--which one doesn't belong? It sounded like she might have experienced, or at least observed in that activity, a clear example of intrinsic motivation to learn mathematics.

Peggy noted that Molly had a wealth of information and was an important resource for Peggy's learning about reformed mathematics teaching. Peggy said Molly was easy and approachable, and gave ideas freely. Peggy wouldn't have asked Molly for ideas if that wasn't the case: "If she was someone else, maybe I'd never talk to her, I'd never ask her, but she's real easy."

Collaboration was an important theme in Peggy's learning. In the year that she thought her mathematics practice had become not "as interesting or as exciting" as it could be, she complained about the lack of teacher interaction around mathematics teaching. She said, "I do think that, to stay up with things, there has to be just a constant dialog." She said it really made a difference for Peggy in earlier years when there was more staff discussion regarding math. Peggy talked consistently about her hopes for more collaboration with fellow teachers, including collaboration around mathematics practice, but described the climate at Timberside as disjointed, with every teacher doing their own thing. She gave the example of how another teacher came to them saying, "Uh, I got to order EXCEL tomorrow guys. You want it or not?"

It was interesting, given Peggy's oft-mentioned desire to collaborate, and how approachable Molly was, that Peggy didn't make more of the opportunity. Peggy got ideas from Molly occasionally. However, despite Peggy's needs in mathematics, and her realization that it was Molly's "mission" to spread reformed mathematics practices, Peggy didn't consistently get ideas for teaching from her, nor ever establish a truly collaborative relationship. Peggy always talked about collaboration, so why didn't she make it happen with Molly, the only teacher she ever considered a good model of mathematics teaching? Some of the activities that Molly shared worked in Peggy's class. Why not get more? Did Peggy feel "math-shy" around Molly?

Overall, there was some lack of coherence and detail within Peggy's beliefs about learning and motivation, and between her beliefs and practice. This is perfectly understandable, given Peggy's background, but it raises interesting issues regarding her feelings of efficacy and her efficacy beliefs.

Effectiveness was Elusive

By looking at Peggy's beliefs, or outcome expectancies, regarding motivation and learning, we have begun to answer my first guiding question of this study: What was the nature of Molly's efficacy beliefs regarding her mathematics teaching? Next we look more directly at her beliefs about the impact she could have on students in mathematics, and how those related to her experiences with reform-oriented and traditional teaching methods.

I Could Make a Difference

I asked Peggy to think about her own mathematics teaching in answering the second Rand question--"If I really try hard, I can get through to even the most difficult or unmotivated students." She answered 1 (strongly agree), and explained her self-rating this way:

> Because I think that [I can do it] if I forget about some other issues like how clean the room is, how neat it is, how much people stay in their seats, and all the kind of orderly things that relate to order. For an example, I think you really can motivate each and every person in the room but you have to keep in mind that there are many different learning styles and you have to go and work with small groups. I think you can do it. I would, I'm convinced. I'm really sure. I think that's what this year has taught me more than anything else has.

She said you had to remember that "everyone doesn't catch it at the same rate," and "things might get a little chaotic and a little out of hand but I still think you can do it." I was interested in the way she stressed the potential impact that "<u>you can</u>" have. I asked her about what impact <u>she was</u> having that year in mathematics. Making a disgusted sound, she answered: "I don't know. I think I, I spun, I, I spun my wheels a lot. I was kind of stuck in the mud not sure what to do. So I think it's been pretty limited."

I was also intrigued by how she equated classroom order with decreased teaching efficacy. She had felt less effective earlier in that same year, when she was "more concerned with how orderly things were." However, once she came "to this realization that I needed to let some other things go that related to orderliness," such as everyone being on task, then she felt somewhat more effective.

Past and future efficacy. Other aspects of Peggy's personal mathematics teaching efficacy beliefs were interesting as well. For example, what she reported during year four of the study about her impact on students in year three sounded much more positive than what she had said about that impact during year three itself.

Also, her efficacy beliefs regarding the future always seemed substantially more positive than her current feelings of actual efficacy. This greater optimism sometimes hinged on getting things she didn't currently have, such as teaching materials, and a class of gifted students.

Real vs. possible efficacy. Another puzzle was how in one interview, she said she felt pretty good about her ability to have an impact in all areas of mathematics, when I asked about that in general terms. However, in the same interview, when asked about her actual impact, she said she didn't feel very good at all about it.

Could Peggy Help Students Like Math?

Mixed beliefs. Talking specifically about her beliefs about her ability to impact students' liking of mathematics, Peggy sounded positive: "Well, I think I think I really can have a lot of impact. I think I can, I can develop of love of it [math] and a willingness to try a willingness to, a lack of fear [of being wrong]." She talked about the "tremendous opportunity to help [form] attitudes" that she had, but then backed off: "maybe not attitudes, but certainly some behaviors in terms of how they approach math and how they look at it." She sounded tentative in hoping students would get what she hadn't: "I'm not that way with numbers but somehow I want them to have that love and that interest."

However, she often sounded pessimistic about helping students like math, noting "that's a really hard thing to do, you know, because a lot of kids just decide early on that they don't like it." She considered it a shame for students to go through "so many years of their life hating something," but her comments made math sound hard to like:

> You know what are we trying to teach kids? Just how to tolerate, you know, a bad situation you know? And I like them to feel that also they have some power, to control how they feel about math that they can make it better.

Mixed effects. My overall impression of Peggy's students was of varying levels of engagement across the mathematics activities I observed, and varying levels of engagement during most activities.

In the last two years of the study, when I was really pressing these issues, Peggy reported her actual feelings of impact on students' liking of mathematics as uncertain or negative. She never gave examples of students who loved math, but gave examples of those who hated it. Peggy concluded one year: "I think I've turned off a few to math, for whatever reason." She also reported her impression that students in other classes seemed a bit more attentive, and seemed to be working on the assignments better than hers.

Reform-oriented practices and liking math. Peggy's use of reform-oriented practices was sometimes met with student interest and enjoyment of activities. For example, Peggy noted that students liked working with manipulatives, math lab, and the interaction surrounding problem solving. She said students "looked forward to" math lab and asked about it, and early in the study, reported "a certain degree of excitement about" problem-solving. However, students seemed to enjoy the problem solving to varying degrees in different years. Also, sometimes she reported that students' engagement in such activities was based on something other than the math itself, such as getting to play with blocks or to talk. At other times, the student engagement seemed to reflect real enjoyment of doing math, as with the "which number is different" activity at the beginning of this case. There was also enjoyment and momentum as students generated equations equaling the "number of the day" during one observation. As Peggy said, "they're just going, going, going, going, going and they're talking about math and that's really what you want to encourage." Finally, she thought she had elicited higher levels of participation by de-emphasizing right answers, because "they're being applauded simply for thinking."

However, reform-oriented practices sometimes elicited negative student responses. For example, when she tried more problem-solving and saw students as less enthusiastic than in previous years, was when she thought she'd turned off a few to math. She believed that the students who were excited and turned on were already that way when they came to her. That year, her goal had slipped from view: "Of course I wanted to build into the students a love of math, but you know, this is the first time I've thought about that since I said it at the beginning of the year." She had the same goal as in earlier years, "but I quickly adjusted it because of whatever was going on in the classroom." This experience also changed how she taught math: "I just do whatever. You know, I do what I can manage to do with the class that I have." She said, "I haven't done nearly the reflection. And I think it shows, in terms of what I might select as an activity." Regarding her attempts to engage the students in reasoning about mathematics, she said students would respond "what do you mean 'why?'" With both parental pressure and that kind of negative student response, she had moved to greater use of EXCEL.

Traditional practices and liking math. Peggy's use of traditional practices sometimes elicited positive student responses. Students were usually fairly engaged in doing the EXCEL worksheets, and some students were very highly focused on completing them. During the last two years of the study, Peggy emphasized how students liked the traditional form of mathematics: "But they like computation, they like to compute. They don't really like to think about things because it involves too much talking and they'd rather go ahead and do it."

Peggy was skeptical at times about student engagement during traditional lessons, believing that part of the engagement in doing the EXCEL worksheet was more about finishing first rather than about doing math. However, she never reported any clearly negative effects of EXCEL or using the district mathematics textbook on students' liking of mathematics.

Summing it up. In Peggy's practice, there was no clear sense that reform-oriented practices were simply more enjoyable or engaging for students than traditional teaching. There was some enjoyment of reformed practices and some students who preferred traditional work. Finally, for both traditional and reform-oriented practices, Peggy often attributed the students liking of the activity to features of the tasks that were unrelated to the mathematics itself.

Could Peggy Help Students Learn Math?

Mixed beliefs and effects. Peggy made very positive statements about her students' mathematical ability: "I have the feeling that my students could hold their own with any other student." She thought this from watching her students who had gone on to the next grades at Timberside, and noting her impact on them, said that she was "was really reaching these kids in a problem solving kind of way." However, as she gave more detail, her claims became more tentative: "I won't say I was reaching the whole class but there were always a few that I thought I was really reaching."

She also said: "I think that my kids are better math thinkers and thinkers about numbers than most students are." Interestingly, this very positive statement came in the same interview in which she concluded that her impact in mathematics had "been pretty limited." Also, her evidence for her students being "better math thinkers" was based on informal conversations with other teachers and their students, and on her belief that since those teachers weren't using manipulatives, their students "aren't gonna' get it."

There was evidence that Peggy's students learned mathematics. In one interview, she pointed out how students had generally understood regrouping using manipulatives. She also noted that students came to her not thinking about numbers in the way she thought they ought to be, but were doing much better on this by the end of the year.

Unfortunately, Peggy gave far more negative examples than positive ones of her own impact on mathematics learning. Thus, on one occasion, she mentioned that students still didn't know the names of the digits in the ones and hundreds places. Even when she had students who she thought understood the ASAT pretty well, she said they really struggled, fell apart, and checked any old answer. In the third year of the study, when she attempted more problem solving, but then returned to doing more EXCEL, she pointed out that students hadn't learned very well to do higher-order thinking. Even some things she cited as evidence of learning reflected fairly widespread lack of understanding. For example, she said students had "sort of" gotten the idea that some numbers measure only a part of something. Shed added, "But then, I don't know, they didn't get tenths and, and then I started talking about fractions and whole numbers and their homework has been indicating they don't even understand fractions."

Peggy also noted that she was way behind other classes in terms of the number of EXCEL lessons taught, and she also had "the feeling that maybe certain students in other classes were showing that they were more capable in math than mine."

Overall, Peggy seemed to have mixed success with students' learning of mathematics. This fit her comments during one interview, as she depicted her impact on students--sometimes they "got" the concept, sometimes they didn't, sometimes they could do the problems, sometimes they couldn't, and "Sometimes they don't remember anything that we worked on."

Reform-oriented practices and learning math. Peggy's experiences hadn't provided her with strong evidence of the efficacy of reformed practices for students' learning of mathematics.

On the positive side, Peggy said you could see the impact of using reformed practices if you set up real problems for students to solve, because the students who only had computational experiences "seem less stable and less interested." More concretely, she felt students had been helped to understand mathematics by the small-group work in the "math lab" activities.

However, reformed teaching sometimes hadn't seemed to work for her. For example, after the "cans for the needy" activity, she noted that a lot of students didn't get it, and their answers didn't even make sense. After the elephants and kings activity, she again noted how problem solving hadn't caught on "there's just not the confidence I guess that I would think that they might have at this time of the year." Even with her seemingly positive example of students learning to do division on their own, they only could generally "figure out a pretty close answer."

None of the specific practices associated with the reforms had yielded clear benefits for Peggy. While she still believed manipulatives were important and wished she used them more, by the end of the study, she concluded that "manipulatives help but only if they're used consistently over a long period of time." She often still didn't use them because "we had to move from point A to point B and I just couldn't take the time." Peer-peer learning raised the issue of what her role was, and what impact she was having. While she occasionally used the overhead, one year she reported it not working because it was "too much eye-hand stuff for my students." Even Peggy's infrequent use of writing in mathematics produced only tentative evidence of learning: "I usually find some hope, some, some feeling of, gee, they're kind of catching on to whatever it is I'm trying to get them to catch on to and they're beginning to see the deeper meaning behind numbers."

Part of the problem for Peggy was that learning was simply hard to see when using reform-oriented practices. While she thought she had gotten a more in-depth understanding of what students knew by watching them in small groups in math lab activities, she said "I think it takes a little bit of a trained eye to see the value of it." She said that in problem solving, you didn't know whether kids were learning, describing it as "almost metaphysical." She had thought about using rubrics to score problem-solving, and thought that would provide a valid measure of student growth, but had heard they were a lot of work. While she assumed that problem solving got students to use "some part of their brain that's probably pretty dormant" otherwise, she wasn't sure whether or not what they were doing in problem solving was "a true expression of math skills." She thought that some impact of this approach was only apparent in the long run: "It's more of a gradual thing." I asked if that meant there was some uncertainty when teaching with problem solving:

> Yeah, exactly. Yeah, when you're teaching with the problem solving it is, it is uncertain. Because you're kind of thinking, "Am I really getting all the sequential kinds of things that they need to have in order to go onto the next grade or in order to do well in the next chapter or whatever the case may be?"

She said this feeling was a reason "why teachers might kind of turn away from it too."

Traditional practices and learning math. Peggy described doing problem-solving as "sometimes kind of floppy," and "kind of all over the place," so I asked whether she got a clearer sense of accomplishment doing EXCEL:

> Yeah, I think you do. I think you just do. You know, and I feel the same way about the textbook. I feel that, yeah, if I went through a whole chapter I've actually done something. Where with the other way, it's kind of like, did you really get everything? Did you really hit on all the things that you needed to hit on? You know, you just, it's very difficult.

Thus, it wasn't surprising that she'd often do a traditional lesson just to feel like she'd covered something.

There were other factors favoring traditional practices. Peggy really seemed dependent on tests such as those from the textbook or EXCEL program to know whether students had really learned or understood something. She also said teaching with EXCEL was much easier, both in terms of planning and execution, and because you were much less likely to lose control of the class than you were with reform-oriented practices. Moreover, the clearest positive efficacy claims Peggy made regarding learning were regarding the way the traditional homework she sent home helped students do better on the ASAT.

However, increased use of EXCEL and decreased use of problem solving at the end of year three hadn't seemed to make Peggy feel more effective, at least as she reported it to me:

> And I think I was much more comfortable [last year] talking about the impact that I was having on the students, than I am this year. I'm not really sure what I've done. I'm not even really sure of what impact I've had. So what if they can compute a thousand different kinds of problems? So what if they know one hundred something and something else, you know, and they don't even know that. You know, I'm really feeling I haven't had, and will not have the kind of impact on this particular group of students in math.

Clearly, students were learning something if they could compute a "thousand different kinds of problems," but Peggy's mixed feelings continued:

> And I think that as long as you use Excel, you may be able to rest easy because you're teaching kids how to compute. But I don't think you should rest very easy otherwise because you're not really giving them a whole lot, you're just not.

I asked Peggy directly how satisfying using EXCEL was in terms of her feelings of impact on students in mathematics:

> [There's] no feeling of impact, or anything like that. I mean, I just don't think so. I think it's kind of neat that they'll probably go into 4th grade knowing how to do a lot of math. But whether or not they'll even retain it during our four weeks of summer vacation is beyond me, because they're not going to be reinforced.

Thus, while progress when using more reform-oriented practices was difficult to see for Peggy--almost "metaphysical," student progress when using the traditional EXCEL was not all that one wanted to teach students about mathematics, and even that progress might disappear over the summer.

Summing it up. Peggy's feelings of efficacy seemed mixed regarding use of both traditional and reform-oriented mathematics practices. She once said her teaching practice was fifty percent congruent with the state math frameworks. She often couldn't make reformed teaching work for herself: "I know how I fool around and how a lot of times I'm just not, I'm not able to pull off what it is I have in mind because it just gets too chaotic or something." Given Peggy's struggles with reformed teaching, it's perfectly understandable that she used the simpler traditional practices quite a bit.

Overall, Peggy's comments about her personal mathematics teaching efficacy were most positive when they were in the abstract--about what could be for her, and most negative when they were about what actually was. Unfortunately, at the end of the study, she reached a familiar conclusion regarding her mathematics teaching: "I'm not sure about my impact."

Future Efficacy

At the end of the study, Peggy explained her approach for the future, how she was going to try to be more effective. "Now, my basic approach to this class and probably every class in the future is that I'm gonna' reach a few at a time and I'm just gonna' work, reach as many as I can." She explained what happened when she attempted to teach in a whole-class, direct instruction way, and didn't try to focus on individuals one or two at a time: "Otherwise you end up with nothing at the end of the day. I mean, I'd rather have ten that got it rather than zero."

Social and Individual Factors in Peggy's Story

One of my initial guiding questions focused on understanding the relationships between efficacy beliefs and reformed teaching in light of the multiple contexts in which these teachers carry on their work. To better address that question, we examine next the role of social supports in Peggy's story. I then conclude with a section on the role of the important individual factors in Peggy's case.

Contextualizing Peggy's case is important, because her story could have turned out better, for Peggy and for her use of reform-oriented mathematics practices. She wanted to be more effective, and sincerely wanted to teach mathematics in a more reform-oriented way. She believed teachers could reach students even when the home environment wasn't good, and believed she could have a positive impact on students in mathematics. Here, in the midst of a massive statewide effort to reform mathematics teaching, why wasn't Peggy more successful in impacting students and in impacting them while using more reform-oriented mathematics teaching practices?

Social Influences, For Better or For Worse

Important social factors in Peggy's story include mixed policy messages, her status at Timberside, modest parental support, lack of models of reformed teaching, lack of teaching tools, and the students she had.

Policy crosscurrents. Peggy had a sense that there was a national need for workers who had understanding, not just rote knowledge. Through county and city-level workshops, and through Molly's presentations to the staff, Peggy also had some knowledge of the reform movements in mathematics, and the state mathematics framework. She occasionally mentioned what she was supposed to be doing in mathematics by referring to state frameworks and the reforms. Peggy sometimes seemed to feel guilty about not doing what the reforms called for, but never seemed to be able to rely on the reforms as a solid rationale for her use of some reformed practices.

At some level, Peggy seemed to "buy into" the reforms, but there were a lot of forces pushing her the other way. When she first came into teaching there was a school-wide emphasis on the basics in her school. The messages she heard from the district were traditional as well. At a workshop given by Southdale's math resource teachers, she and others were told that understanding is "an ideal, and when you can, you capture it, but basically you need to cover this material." Even the majority of teachers at Timberside seemed to favor traditional practices. Peggy explained how other teachers didn't want to use the manipulatives and "don't want to fool around with all this amorphous whatever-it-is." Finally, testing was not driving reformed teaching. Regarding the defunct CLAS test, Peggy noted that if that test were still in place, that "would really have a tremendous impact" on how teachers evaluated their effectiveness. Peggy thought the lack of a reform-oriented assessment tool was a crucial issue: "That's one reason why people don't want to teach problem solving because it's not going to be measured on the test. Not on the ASAT." She said, "you need some kind of assessment" to follow a reformed approach, but without that, said, "right now, no one is buying into it."

Little clout, and the school context. While both principals at Timberside supported reform-oriented teaching, they also allowed teachers to use more traditional practices. Peggy was in a very different position at Timberside than Molly, who was a well-respected veteran teacher. Peggy had only been there a few years, and had struggled with the noisiness of her classes during that time. She was one of a handful of African American teachers in the predominantly White school. In many ways, Peggy didn't seem to be in the same position as Molly to take a stand for reformed practices. One of her explanations for using EXCEL is consistent with someone in her position: "I did it [EXCEL] mainly because I was just scared. I was just afraid, not mainly, but I did it in part because I was afraid to be different." Also, she described the reformed approach as "hard to teach," and thought you didn't do it alone. Peggy thought it required "the whole school believing and working towards that to some extent." Along these lines, Peggy emphasized her need for "outside support."

Teaching with little parental support. Peggy didn't seem to have a lot of support from parents in carrying out her teaching. While she once described a father who had gotten very involved in helping out with the math lab, I never saw parent helpers during my observations, and she complained about having very little help from parent volunteers.

Parents who volunteered got to make requests for what teacher they wanted, and this teacher request process provided negative feedback for Peggy:

> It's like I'm not even in the running, you know? I'm thinking "Gee, I'm busting my buns here," and I'm really working hard, but I just get the feeling that I'm not exactly at the top of the list in terms of teacher effectiveness, as far as the parents are concerned.

Not being most parents' choice had turned Peggy off. She said that because of that, she didn't "get off the dime" one year in terms of her teaching.

A need for modeling and coaching. When asked about what type of learning experience would help her be more successful with reformed teaching, she repeatedly said she would like to have a mentor to model practices for her and provide her with feedback. Unfortunately, no such mentor came with the reform movement, and Peggy seemed to be trying to learn to teach in reformed ways largely on her own. She said that aside from Molly McCarthy,

> I can't think of any positive model that I've ever had in math. Not even one. Not even the people who come out here from, to do in-services. I think they still go too fast, and everybody tries to show off what they know.

Peggy considered Molly to be an excellent model, but Peggy never mentioned getting to watch Molly teach, even though her class was just a few steps away. Peggy also pointed out how Molly had "a different population of kids." However, Peggy said Molly had "tremendous resources" and Molly's activities seemed to work with Peggy's students. Peggy's most significant success with reformed teaching seemed to come from doing the "math lab" activities that Molly provided for Peggy and Beth.

It was unfortunate that Peggy hadn't had a more substantial learning experience involving the mathematics framework. Similar experiences had been helpful to her: "I have a much better sense of how to view art with kids that I did before and I got that directly from the state level framework that I'm involved in." Similarly, after being "a little fuzzy" on the social studies framework, she attended a three-week institute on the social studies framework. A year later, she noted: "I think I do a better job than most [teachers] in social studies because I spent [time] with the framework over the summer." Institute participants had to do a "fairly major project" and she noted the impact of deep involvement with the framework: "I think that reading it and going over it and hashing it out, I think is important."

Good tools needed. Peggy made it clear that having more teaching materials would improve her impact in mathematics. In fact, her second wish for what she would want if teaching mathematics on a deserted island was for more tangible resources for the classroom--like mathematics games, so she didn't have to make them on her own. When she imagined teaching in a much more reform-oriented way, she didn't know how she would fill in all the gaps, and said she'd have to come up with "tons" of teaching materials to do that. While she had picked up a few activities here and there from Molly and from workshop experiences, this was hardly enough to arm her for a full year of reform-oriented teaching. Peggy pointed out that not all teachers had the gifted budget Molly had, so they couldn't all spend a fortune in their rooms.

However, one of the problems with the reform-oriented teaching tools Peggy did have was that they didn't give much guidance on how to teach when using them. She said how using them was more a matter of trial and error, and how she would simply stop using those things that didn't go well. This trial-and-error process sounded similar to the students' experiences with discovery in her classroom. Thus, Peggy's progress was slow, and success was uncertain.

It was significant that Peggy didn't have tools to indicate student progress when attempting reformed teaching, and had to wait for tests at the end of the week to know if students had learned. This brings to mind the discussion in the opening chapter about feelings of impact on students often being teachers' most important source of satisfaction from teaching (Ashton, 1986). Without a tool to show evidence of student growth, it is understandable that reform-oriented practices failed to gain more of a foothold in Peggy's teaching.

Different students learn differently. While Peggy emphasized student differences in motivation and learning, it was hard to know how the composition of students in Peggy's class affected this case.

While Peggy's students weren't the "cream of the crop" at Timberside, they still seemed like a pretty average group, some higher ability, some lower. Only a couple of the students in any year seemed a bit difficult to manage, and most seemed like pretty nice third graders to me. I wouldn't have expected any teacher to be able to help Peggy's students learn as quickly as the students learned in Molly's class, however, they seemed capable and willing to learn.

Peggy gave mixed messages about the effect of student ability on her impact as a teacher, at times saying gifted students were more motivated to learn than her students, and at other times saying she wouldn't expect them to be any more responsive than hers.

Similarly, she once compared the students from the very-low-income Columbus school to the students at Timberside, and said that the students didn't make a difference in your impact, the teacher made the difference. However, she also said you could have more impact with smaller classes, with more homogeneous classes, and how it was easier to impact students who simply were more receptive to learning.

Peggy Behind the Scenes

Peggy's story was influenced not only by a range of social factors, but also by her knowledge, the time and effort she put into teaching, her overall experiences in teaching, how she interacted with others, and her understandable focus on her own performance.

A need for conceptual resources. Beyond not having the material resources that characterized Molly's case, Peggy hadn't learned or been taught many things that would have made reform-oriented mathematics teaching more successful for her.

Peggy said her own "lack of math knowledge" made math less of a priority in her teaching, and limited her effectiveness. She thought, "Molly was a better math teacher because she had a better understanding of certain mathematical principles that I just don't." This lack of knowledge also made planning harder: "I have to kind of read what someone else said about the understanding of what you're trying to get across rather than kind of seeing it on my own because I don't have this basic understanding."

Peggy told a poignant story about how her lack of knowledge affected her experience during one of the school's Family Math sessions, which was run by Molly:

> There are parents there and kids and the problems were pretty complicated, and I really did feel kind of math shy. I felt, you know, kids would come to me, or I had the option of kind of going into the crowd and sitting with different families and things like that, and I really avoided that. I handed out pencils and stood. I watched people sign in. And I even remember that night; thinking to myself that I just didn't feel that capable, because I really didn't understand some of the problems.

In one lesson I observed, a student asked if 114 minus 94 equaled twenty. Peggy said she didn't know--"What I'm finding is, I can't do it very well in my head," and asked the students to do it quickly. Peggy worked the problem on the board, and said twenty was correct, and then asked others if they got the same answer. In the same activity, I thought she seemed unsure as to whether twenty divided by twenty plus nineteen also equaled twenty. Peggy acknowledged that she encountered students' answers or reasons she didn't understand--"It did happen quite a bit in third grade." Finally, even though she wanted some sort of rubric for assessing problem solving, she may have needed more subject matter knowledge to be able to use this well. She had tried a rubric for assessing writing, but saying it didn't work well, and had abandoned it in favor of a blue ribbon, red ribbon approach.

With Peggy's negative experiences in mathematics, she believed mathematics was fairly unappealing, and expected students to not like it. An understanding that math can be enjoyable and rewarding may have helped her, along with knowledge of how to make it intrinsically motivating for students.

Peggy seemed to have a number of unhelpful conceptions about reformed practices. Expectations of chaos from using manipulatives and belief that the discovery process was so very slow probably did not help her feel successful with reformed practices. If discovery may not happen until the child has moved on to the next teacher, what <u>is</u> the learning that a teacher using these methods can take credit for, and feel proud of? Also unhelpful was her view that the reforms suggested a fairly passive teacher role.

In general, Peggy could have benefited from learning more about using the practices associated with the reforms. Learning to teach using manipulatives (and manage the class as well), learning to guide discovery and how to teach problem-solving strategies all could have helped her be more successful. She also could have benefited from learning how to use some of the tools she had, and figuring out what else she needed. Peggy really struggled with identifying what she would want first if teaching on a deserted island: "I'm not sure what I would ask for." I interpreted this to mean she wasn't sure what tools were central to her mathematics practice, a clear contrast to the case of Molly.

Finally, Peggy sometimes talked about not understanding students, and seemed surprised by some of the things they did, such as playing with materials she gave them. She acknowledged having adult-level expectations of them at times, and may have been helped better understand what to expect from children by learning more about child development and learning.

Time and effort. Putting time into her practice was an issue in Peggy's case. Saying she worked about an hour a day on planning, she noted the connection between time and efficacy: "If I had more time to prepare, I think that that would certainly improve the impact of what I do with students in math." She said she was not a good budget person in terms of time, generally didn't take work home, and liked to spend time with her daughter, and on her hobbies. All of these factors meant less time for planning. Of course, lack of time made her choose the more-expedient EXCEL more often: "A lot of things you do, you do [it] because it's expedient. You know, it's not because it's better or worse. It's just expedient. It's what's available."

Lack of time also translated into lack of organization, which she said undermined her efficacy in mathematics teaching. She said that not being prepared made more of a difference with the kind of students she had, and that she got lots of behavior problems when she wasn't prepared.

Peggy said that when she took more time for planning, it definitely made a difference the following week, and thought she would need an additional five hours per week on planning to feel comfortable with her teaching. Describing her own style, she noted "I really sometimes don't think that far ahead and I don't think." However, Peggy didn't think planning was a panacea, and gave an example of an activity which she had planned carefully, but which was still chaotic and loud.

Also, in spite of acknowledging that her lack of mathematics knowledge made her less effective, she noted that she wasn't going to go out and improve her background in that area.

Finally, Peggy noted that she might give up too easily on some of the new methods. She thought if she had tried a few of the methods a few more times, that she probably would have gotten the hang of them, and could have incorporated them into her practice.

Broad struggles, a few successes. Elementary teachers teach many subjects, and unfortunately, Peggy's story in mathematics teaching took place in the context of her other struggles with teaching. She was the most specific in describing what she thought when teaching didn't go well:

> Yeah, do I need to quit? Yeah, I think about that. I'll say, like I say to my daughter, I think the other morning I went, "I'm just not a very good teacher." Yeah, I said, "I'm just not very good at this." You know, this is kind of getting on my nerves. I'm just, I would think I would be far better than I am. It's not very good.

Peggy would say she wanted to quit, and would think "maybe I need to go to an inservice, maybe I need to talk to the principal." Sadly, she had these feelings of frustration even after eight years of teaching. Peggy wasn't satisfied with her impact, didn't like her use of rewards and punishments, or the way she would lose her patience with students. Her description of feeling ineffective was poignant: "I would go home just feeling so low in the, the heaviness of the whole experience of the day. The way I raised my voice, wondering if any one heard me." These feelings fit with her comments about students she couldn't reach, students who didn't understand what she said, and with her tendency to blame students for their failures--a traditional indicator of negative efficacy beliefs.

There were some bright spots in Peggy's teaching. Reading and writing were areas where she felt she had more impact. She said she was good at gauging students' progress in writing: "I can see the impact that I have on students in terms of reading and writing that I don't really so much see in math." She gave examples of things students had learned in these areas, and felt she could take credit for their learning because she knew of specific strategies that she'd used to help certain students.

Not helping others help her. Like many people, Peggy didn't always go and get the help she needed from others, and this showed up in a few ways. For whatever reason, she didn't seem to have elicited significant parental support to help her carry out her teaching. Perhaps more significantly, she didn't make full use of the resources available from Molly. While Peggy said how she would have to come up with "tons of" materials or activities for teaching in a more reform-oriented way, Molly was right next door, and wanted to share. Peggy explained her decision to use EXCEL instead of a more reform-oriented approach this way: "I didn't know how I was going to fill in the gaps, I just didn't think I could really handle it on my own." After she left Timberside, she thought she would have gotten even more ideas than ever that year from Molly, had she stayed at the school. She also explained why she didn't make more use of Molly as a resource:

> When I kind of draw back from people, it's because I see them giving more than what I'm returning. Like I feel kind of guilty. You know, like, sometimes I would withdraw, you know, kind of pull back from Molly a little bit. Because I didn't have anything to share and I felt really bad about that so, [I] kind of pull away from her a little bit and same with Beth and everybody else. I've always been like that. When it looks like I'm not giving my part, I just, well, I pull away.

It would have been interesting for a number of reasons to see what would have happened if Peggy had let Molly help her more. Molly described how reform-oriented practices sometimes didn't work because teachers go on too long with an activity, or give every student a turn to share, and thus let the activity get bogged down. These were precisely some of the problems that I observed in Peggy's classroom, but which Molly had learned how to avoid. Seeing what else Peggy could have learned from Molly would have been interesting.

Worrying about appearances. Perhaps for a variety of reasons, Peggy seemed self-conscious, saying she thought all the time about how she was doing while she was teaching. She seemed self-conscious about her class making noise, and also was self-critical, saying she would "get so disgusted" regarding her own performance. She also talked a lot about feeling guilty, especially about being behind other teachers in the number of math lessons covered. Feeling guilty for that was especially unfortunate, since splitting her time between the two approaches meant she would always be behind the traditional teachers on the number of EXCEL lessons covered, and behind the reform-oriented teachers on problem-solving or other reform-oriented goals. Unfortunately, focusing on her own performance could be a very negative experience for Peggy:

> I would make myself sick. Why did I do this? How did I do it, what did I do to that kid? How did I appear to that parent? I mean, parents tend to like me anyway. Yeah, what did [Debbie, the principal] think, what did Molly think? It was making me sick. It was making me absolutely ill.

Peggy was going to teach gifted students in her own self-contained classroom the year after this study ended, and was also going to get to team-teach with another teacher. It was nice that those wishes of hers were going to come true. However, it was unfortunate that this small slice of her story in mathematics teaching couldn't have turned out a bit better--for Peggy, for her students, and for the mathematics education reforms.

A Normative Look at Peggy's Teaching

Compared to Molly, Peggy was less aware of the reforms and had incorporated into her practice more of the elements of the reforms. She made use of manipulatives, created opportunities for discovery and peer-peer learning, and tried to facilitate some discussion regarding mathematics. She engaged students in mathematical problems that were embedded in stories, and made attempts to connect mathematics to real life.

However, Peggy was quite aware that her teaching was not wholly reform-oriented. Peggy didn't believe that reform-oriented methods necessarily worked for all students, and wasn't sure that they addressed computation adequately. Thus, her practice involved an alternation between very traditional teaching and attempts at reform-oriented teaching. Limited by her knowledge of mathematics and of reform-oriented methods, her attempts at reformed teaching still focused on eliciting and supporting correct answers. She acknowledged that she wasn't sure how to guide discovery, and didn't seem to know how to teach students problem-solving. Deep exploration of students' reasoning was never observed, and Peggy didn't seem to know how to ask thought-provoking questions in mathematics, even at a simpler level. While Peggy had interest in the reforms and opportunities to learn about reformed teaching, her efforts at reformed teaching relied too much on students discovering mathematical truths for themselves. Thus, while her version of traditional teaching seemed to be inspired too much by the tradition of Skinner, her efforts at reformed teaching seemed inspired too much by the romantic tradition of Rousseau.

Chapter Four

THE CASE OF PHOEBE NOTION

Phoebe Notion, Who Preferred Teaching Procedures

Watching Phoebe's Teaching of Mathematics

The morning lesson was already underway as I arrived for my first observation in Phoebe's classroom. Students were estimating the product of decimal problems written on the board, minutes, one boy was sent out of the room for misbehavior. Some students were working, but many were not. Phoebe, sounding exasperated, said "All right, finished or not, let's have your attention up here. People we've been on this for three days." She began to call on individual students, asking them to what whole number they should round each number, in order to estimate the answer. After doing a few of these problems, she asked some of the students if they understood--a few shrugged, one said "no." Phoebe began to review the homework from the day before.

Phoebe taught fifth grade in Columbus School, in one of the poorest and most crime-ridden neighborhoods in Southdale. She had been there since Eisenhower was president, and had watched the area change into a more diverse and a more troubled neighborhood in which to live. To me, many of Phoebe's students seemed to have behaviors that made them challenging to work with, and Phoebe seemed weary from the struggle of working with them. Nevertheless, she had some spark, some optimism.

Mathematics was not her favorite subject to teach, but Phoebe had been a good student in mathematics. She had a clear sense of her own approach to teaching mathematics, which was oriented towards procedures. She had told students in the 1970s to not worry about the "whys" of mathematics:

> Don't ask me why you do this--when you inverted the fractions--don't ask me why. Just do it. This is the way you do it. And I do that because I never understood why. Well, I still don't understand why you have to invert--that doesn't make any sense.

How did Phoebe, in her last four years before retirement, teach mathematics? Her own experiences as a student and teacher emphasized procedures, but many around her were trying to teach in ways that emphasized conceptual understanding. What did she know about the mathematics reforms, and what happened as this very traditional teacher encountered them, while teaching in a very difficult setting?

The following examples illustrate Phoebe's mathematics teaching, after which I examine how her theories of student motivation and learning help us in understanding her practice.

Working Long Division Problems

After a long and loud transition, Phoebe started math by writing 503 divided by 25 on the overhead in long division form, and asking students to copy it down. A few students asked what page they were on. Phoebe said, "I didn't say a page." When another students asked, she replied more sternly: "I didn't say a page! Copy this down!--Now!"

On the overhead, she covered all but the 5 in 503, and asked the students if 25 could go into 5. They said "No." She showed the 50, and asked if 25 could go into 50. Students said "yes." Phoebe said "So my answer will start here [indicating the tens column]," and wrote 25 x 2= 50 vertically as she talked through the multiplication. Then she wrote in 50 under the 503. Phoebe continued, "step number 4," and some students called out "Bring down the number." Phoebe replied: "No, no this is extremely important that you look at the remainder you get when you subtract. Compare it's smaller, so now I bring down the 3. How many 25s in 3?" Students replied "zero." Phoebe asked them to multiply, "zero times 25, zero subtract three. Get this on your paper."

Phoebe turned to Regina, and said sternly "I didn't tell you what page Regina, because I don't want you to have 'what page.' When I'm ready, I'll let you know."

Later, when dividing 39 by 13, Phoebe reminded students of the steps in doing long division. Then they tackled 5,520 divided by 23. She asked, "Will there be thousands in the answer?" Many students said yes. She asked again "Up here?" and they quickly shifted their answer to "no." She said, "No, it doesn't go into thousands, does it?" I couldn't tell whether students understood the place value issues here, or changed their answer because her tone of voice implied they were wrong.

Phoebe continued her pattern of asking them what steps came next as she worked through a few more problems. Her pace became so brisk that I could just manage to copy down what she wrote. It was difficult to follow Phoebe's instruction because the numbers were off the projection screen at the top, and too low at the bottom to be seen. Phoebe firmly and immediately corrected student errors. For example, when some students said that eighty went into seventy-six one time and others said it went in zero times, she quickly responded: "Zero! 'Cause there are no eighties in seventy six." She sprinkled her teaching with hints, such as "the remainder can be as big as one number less than what you are dividing by. If it's the same as what you're dividing by, then it's got a mistake." Another tip was that when they have dollars and cents on problems in their math book, they'd usually have nothing left over as a remainder. This may have been true about problems in this text, although it is not true of problems in general.

Phoebe asked what the first step was for dividing $1.82 by 26. "Any dollars?" After a "No" chorus rang out, she asked "Any dimes?" When this was greeted by a "Yes" chorus, Phoebe asked in a tone of disbelief--"You're telling me there are going to be dimes?!" Immediately the student chorus replied "no," and Phoebe emphatically said "No! So you put a zero there."

For dividing 39 into 31,551, Phoebe asked them which column their answer would start in. Her inflection remained high as she said "Is my answer going to start in the ten thousands column? The thousands column?" Her inflection then dropped as she said "the hundreds column?" Many students then said "yes, the hundreds column." She said that would give them an idea of where to start with their answer, and told them to "work" the problem.

In these examples, Phoebe helped students to arrive at correct answers by simple modeling on the overhead, correcting wrong answers and saying the correct ones, asking questions that implied what the answer was, and by using inflection as a cue.

Late in the lesson, there was a modest amount of off-task activity, as Phoebe divided $80.36 by 26, yielding an answer of $3.07. She initially had a remainder of 62 cents, but students said this was wrong, and she corrected this to show 52. Students said that this was wrong--it was too big a remainder. Phoebe asked Regina "You're telling me 'yes' and Kayla's telling me 'no'--what's wrong?" As several other students called out, Regina said "It's bigger than twenty-six." Phoebe asked, "What tells you that's bigger?" Regina said "The two and the five." Phoebe replied, "What step tells you that's bigger?" Students said, "Compare," which Phoebe repeated. She re-worked the problem to yield $3.09 and remainder zero. Regina asked whether there wasn't a remainder of one. Phoebe said, "No, no remainder," and announced the next problem.

One of the girls had begun to call out answers, and Phoebe said, "Shut your lips now, I'm tired of hearing your chatter." While many students had been talking and calling out answers or exclamations or side comments, most students were still paying attention to the board as Phoebe did another problem. The bell rang and students called out "Recess!" Phoebe worked through with them the problem that she had started, then told them to put their math books away and get ready for recess.

During this lesson, Phoebe was quite stern. She focused on students doing procedures and getting correct answers, but didn't emphasize understanding. She used various strategies for correcting or steering student responses. Her pace and use of the overhead made it hard to follow her work. This lesson was characteristic of much of the mathematics teaching I observed in Phoebe's classroom. How did this lesson relate to her theories of students' motivation and learning?

Phoebe's beliefs about motivation. Phoebe believed that students preferred the traditional computation found in the preceding example to the more reform-oriented practices, which involved playing with materials: "They just love the basic computation--for some reason, that's math to them. This other stuff--playing with the pieces, isn't math."

Secondly, Phoebe's approach seemed to rely on a basic compliance approach for motivating good behavior. Phoebe described herself as coming from an era when you just did what you were told. One of her main strategies for motivating good behavior was to demand it. Phoebe was very stern as she ordered individuals to shape up. I thought she seemed surprised when students weren't more obedient. She certainly expressed this in interviews, as she observed that students today don't respect teachers, and some of them don't listen to teachers.

Phoebe's beliefs about learning. This example reflected Phoebe's theory of student learning. She was very focused on the learning of procedures. She used a lot of repetition, in the belief that this would help her achieve one of her teaching goals--"to just make it [mathematics] very mechanical so they don't have to think."

Making math mechanical for students involved getting working lots of problems correctly, with her guidance, and focusing on the steps involved. For example, when a student had pointed out that the remainder of 52 was larger than the divisor 26, Phoebe was emphatic in eliciting from the student what step in the process told them that 52 was larger than the 26.

This example also reflected Phoebe's belief in the role of modeling, reinforcing, and correcting students' responses. In providing a correct model, and repeating correct answers and correcting incorrect ones with an emphatic "no," Phoebe seemed to be following an applied behavioral approach to teaching. She used corrections, questions and a tone of disbelief to quickly guide the students to the correct answer. I was convinced that a number of students simply knew how to read her tone of voice, and provided the correct answers by relying on these cues, without even thinking about the math at hand.

Phoebe's practice didn't emphasize understanding, and there were a few ways in which her emphasis on procedures may have actually created problems for understanding. First, Phoebe's pace was so fast that I was impressed that so many of the students were simply able to copy the problems as she went along. Her pace hardly allowed time to think, although perhaps this is one strategy for making math "mechanical." Second, Phoebe referred to numbers in problems without respect to place value. Thus, she commonly only showed one, two, or three of the furthest left numbers in the dividend, and referred to them without reference to the whole number they were part of. For example, she called 310 "thirty-one." Third, she asserted facts that I wasn't sure students understood. For example, dividing 8413 by 14, she had only the 84 showing. She wrote 14 x 8 = 112 in the margin, then subtracted fourteen from 112, got 98, and said "So it's gotta' be six." I wondered if any students followed Phoebe's calculation or conclusion, especially since she said her students struggled with their basic math facts. Fourth, there were a few curious aspects of the lesson. For example, she told students that when they have dollars and cents problems in their math book, they'd usually have nothing left over as remainder. This may have been true for that math text, but is not an accurate or helpful point for sense-making in division with money in general. In addition, students frequently called out wrong answers. I got the impression that calling out wrong numbers reflected some misunderstanding, but was also a form of sport in this room. Calling out answers, especially if it could get a laugh from classmates, as it sometimes did, made sense as a response from students who often did not really understand the math they were doing

Phoebe's use of the overhead was also curious. She found it easier to sit on a stool at the overhead than to roam the whole chalkboard. Phoebe had problems with her hips and knees, and had hip replacement surgery in the last year of the study. She walked with quite a limp, and was constantly in pain. In using the overhead, the image was sometimes projected too high, or too low to see, or was slightly off one edge. I didn't think she realized that the numbers could be hard to see from the students' perspective in their seats, and when students complained about this, she replied "Well I can see it, do you want glasses?"

Finally, I thought this activity reflected something else about Phoebe's theory of learning. She acted as if mathematics was transparent, and should be easily apprehended by students. Thus, when she was figuring out how many times fourteen goes into eighty-four, she quickly did some math on the board, and then concluded "so it's gotta' be six."

Phoebe's own motivation and learning. Phoebe's view of mathematics as procedural, and her "action-oriented" approach to teaching was consistent with what she wanted from learning experiences for herself. Reflecting on past struggles as she learned to use computers, she remarked: "So, but to tell me why this does this or why I have to press this button to do this, you know, I could care less. If pressing this gets me my result, I'm a product person." Phoebe's style may have influenced her "results-oriented" teaching practice.

This example is a good representation of Phoebe's style and traditional mathematics teaching practice. It highlights her beliefs that students' love of basic computation is a motivating factor in liking mathematics. Did she have any beliefs that would suggest that reform-oriented practices might support student motivation as well? Phoebe believed that modeling, correction, and repetition were crucial for mastering computation basics. I wondered if there would be more to Phoebe's beliefs about learning if we examined her attempts to use more reform-oriented teaching. Did she focus on understanding, or believe that students learned differently, when mathematics was taught using manipulatives?

Making and Comparing Shapes with Tangrams

During my final observation, Phoebe's mathematics lesson involved a series of activities using tangrams. Phoebe distributed sets of tangrams and worksheets from a tangram activity workbook. She told the students to fill in pairs of shapes on the worksheets with their tangrams, and asked them to determine whether the pairs were the same size--by looking at them or using the tangrams to measure them. The students' engagement was minimal during this activity. I wondered if they were bored because the lesson was too easy, too convergent, or both.

Next, Phoebe asked the students to use all seven tangrams to make the letter C, pictured in their workbook. Then she asked them to make other letters using all seven tangrams, then a square. Students who finished these tasks quickly began to make other shapes.

The next activity focused on size. Following the order of activities in the tangram workbook, students used two small triangles to measure other shapes, to determine if they were the same size. Phoebe stopped the lesson once, when the students' talk strayed from the activity. When one boy said two same-size shapes weren't the same size, Phoebe told him how to work the problem using his two small triangles. Later, Phoebe asked students to give the thumbs up sign to indicate that two pictured shapes were the same size. Then she said, "I see some people without thumbs up, that tells me you haven't done it yet." I wondered if students might have done it, but had concluded the shapes were different sizes. Phoebe read a statement from the workbook that said that figures could have the same size and not be the same shape. Even with manipulatives, Phoebe's practice emphasized modeling, telling, and correcting, rather than discovery.

Students continued to measure various shapes using the small triangles, noting how many triangles were needed to fill a shape.

Phoebe responded to a student's observation that you could use the squares for measuring too. She said, "You could use the square, because the square is equal to how many?" The students said "two." Phoebe noted, "Two of the small triangles." This seemed to be the most understanding-oriented comment I had heard during the lesson. I thought it was interesting that it grew out of a student's discovery. Two students were talking about the shapes--one said he'd "bet anything" that the last shape pictured wasn't three triangles. The second student used two small triangles and a square to cover that shape. The first student pointed out that the square could be divided into two small triangles. Then the second student erased the "3" he had written down and wrote "4."

When half the students gave a "thumbs up" to indicate that two figures were the same shape (they weren't), Phoebe asked again if they were the same shape. When thumbs stayed up, she said "Not size, shape." Many students still indicated they were the same shape. "A and B are not the same shape, people," Phoebe exclaimed emphatically. When only a few students responded, but responded correctly to the next question, Phoebe said "All right," and moved on. She continued this approach with other problems. When students called out different answers, Phoebe simply stated the correct answer. She seemed exasperated when two students could not figure out which of two complicated shapes was larger. Phoebe asked, "Just looking at them, which one is larger?" The students didn't indicate that they knew this answer. Phoebe seemed puzzled by their lack of understanding, as she did later when she gave a student a funny look after he indicated he thought two shapes were the same size. I wondered if Phoebe thought such knowledge was transparent. Even though I feel I have excellent spatial skills, I wasn't sure on first glance which shape was larger.

Phoebe's instruction continued as she either told them, "If the shapes are the same size, then you should be able to use the same pieces to cover both." She repeated this statement a few times. Although it was true for the way these tangram worksheets were constructed, it isn't a general principle about shapes and size. As the activity continued, a few thumbs went up to indicate that two shapes were the same. Phoebe said "No!" I wondered again whether some students were giving wrong answers to make this lesson more interesting, while others were just confused.

At this point, as Phoebe turned to talk with another adult in the room, some students were talking, some were racing to make the shapes in the book, and others were just making their own shapes with the tangrams. It was fairly noisy, and she turned her attention back to the class as it got louder: "Hands up, mouths shut." As misbehavior and noise continued, Phoebe tried to get the class quiet--"I should not have to raise my voice to anybody!" She sent two students out of the room for misbehavior.

Then she told them that she would read a story about Grandfather Tang. She passed out worksheets with printed shapes that appeared in the story.

As she distributed worksheets, noise and misbehavior continued. She said "I am serious, I will send a whole table away. I will find rooms to put you in. Now sit still and be quiet."

The story was about Grandfather Tang telling his granddaughter Sue a story about two girls who had magical powers, and could change themselves into different animals. Phoebe asked the students to take turns with their partners making the shapes in the story. Students made the animals described--a dog, turtle, squirrel, hawk, crocodile, etc. They seemed a fair bit more interested in this activity than in the shapes they were making earlier.

Phoebe told the students to not work ahead, but many did anyway. They seemed more engaged in figuring out how to make the shapes, and didn't seem to be paying attention to the story. When it got really noisy, Phoebe said, "Stop the chattering, so you can hear the story."

One boy, who was trying to make the turtle, said, "The square won't go in," Phoebe said "Excuse me, but the square will go in. All seven tangram pieces always go in--nothing extra, but they all go." Later, as she watched a boy trying to make the hawk, she provided more direct correction: "The big ones are right, the rest are wrong."

Phoebe tried to control the pace at which students made shapes, and tried to keep them from going ahead. However, it seemed to be those students who were waiting for others who were causing most of the disruptions. Unaware that Carla had made the turtle about five minutes earlier, and had moved on, Phoebe told Carla to make the turtle. Carla made a face, put one piece on, and looked around. Phoebe was still watching her and told Carla she was waiting to see the turtle. Carla then made the turtle shape again.

The activity finished with groups making a picture of the grandfather and a tree, using two sets of tangrams. Phoebe kept saying "wrong, wrong, nope" to a group that was trying to make the tree after others had finished. As they struggled for a few more minutes, Phoebe sent another student out of the room for misbehavior. Then she collected all of the tangrams and that was the end of the lesson for that day.

Phoebe's beliefs about motivation. This example directly reflected one of Phoebe's theories about student motivation--that students "love the tangrams." She did not elaborate, except to say that tangrams were "fun."

Phoebe's beliefs about learning. Although this lesson involved manipulatives, it was more focused on procedures for measuring, and correct answers about shape and size, than about conceptual understanding. Thus, this lesson is another example of Phoebe's emphasis on doing, and on correct answers. She did believe that using manipulatives had some role in helping students' understanding of some things. For example, she had concluded that students had come to understand shapes and geometry through "looking at those pattern blocks," and said, "I think they would understand volume if they played with the cubes."

I thought the fact that Phoebe provided regular corrective feedback to students was especially interesting given the "self-correcting" nature of these materials.

Phoebe's own motivation and learning. I thought it was interesting that geometry and making shapes was the place in her mathematics where Phoebe seemed most comfortable with using manipulatives, since one of her own passions was quilt making. The shapes students made here seemed reminded me in a way of the quilts she made with students, and just as her own art form was constrained to fit within standard size squares, students here were making shapes fit within a pre-established form, rather than creating free-form shapes.

Fractional Parts of the Whole

In this lesson, Phoebe led the class in a series of activities that emphasized fractional parts of the whole. Given equations (e.g., 1/3 + 1/3 + 1/3 =1), students were to divide squares into the fractions that represented the equations. The following examples are representative of the entire lesson.

Phoebe read the directions for the next set of problems from the workbook: "It says that each large square is worth one. Label the fraction parts in the squares in the first two rows." Students correctly showed 1/3 + 1/3 + 1/3 = 1. Referring to the representation one boy had drawn on the overhead, Phoebe asked "OK, how many thirds do I have here?" The student said "three," and Phoebe said "And then three thirds equals what?" Students called out "one whole, one-half, one-third, one," but Phoebe wanted the boy at the overhead to give the answer. He said "one-sixth, six." Phoebe asked if there were six pieces there, and what they equaled. Another student called out "nine." The boy at the overhead repeated "nine." Phoebe scolded the boy at the overhead for parroting this response and sent the student who was calling out answers to sit in the corner.

Phoebe asked the boy at the overhead what each square equaled. He said one, and she asked, "Therefore, three thirds is worth what?" There was a pause, and then Phoebe answered her own question--"One whole!"

Then two students came up front and represented dividing the square into one-sixths in two different ways, and a third girl showed how to divide a square into one-ninths.

Next, Phoebe asked a series of questions. She asked Kayla to write responses on the overhead, as she asked her how many thirds equals one, how many sixths equals one, how many ninths, etc. Kayla wrote: =1=3/3=6/6=9/9=2/2=4/4=5/5=100/100. Phoebe asked "Looking at what she has just written on the board, what can you tell me about one whole?" She called on a boy who said "One whole is ..." but Phoebe cut him off, saying "How do you know when you have a whole?" The students mumbled something quietly. Phoebe repeated "No, when you look at a fraction, how do you know when you have a whole?" Phoebe asked Regina how she knew that all those numbers equaled one. Regina said, "It has to be the same on the top and bottom." Phoebe asked her to repeat this for the class. Regina said: "It has to be the same fraction on the top and on the bottom."

Phoebe showed three squares on the overhead. Written under the squares, from left to right, were the equations 2/6 + 2/3 = 1, 4/6 + 1/3 = 1, and 2/3 + 3/9 = 1. Phoebe pointed out how the publishers had put dots on the edges of the squares to give the students clues as to how to divide them into the proper fractions.

A girl who was working the first problem at the board divided the square into three thirds. Phoebe said, "OK, you've got three thirds. They want to know how two-sixths plus two-thirds, so what are you going to do to one of those thirds?" The girl drew a bisector through two of the thirds. Phoebe said, "That's more than two sixths, you only want two sixths." The girl erased one of the lines, labeled the two sixths correctly, but labeled the middle one third as "1/2." Phoebe said, "I think you know what you are doing." Addressing the class, said asked, "Is that 1/2?" A student said it was 1/3. The girl wrote 1/3 and 1/3 into the middle and right-hand thirds. Phoebe told her to stand back and look at her drawing: "Do you have two sixths plus two thirds?" The girl did not respond. Phoebe repeated the question and the girl said "Yeah." I wondered if this student understood, or if she was largely figuring out the correct response by interpreting Phoebe's comments and tone of voice.

Working the second problem another girl incorrectly divided the square for the second equation (i.e., 4/6 + 1/3), using a left-to right bisector. Phoebe said, "You want four sixths and you want one third. So that means you're going to have to divide the whole thing into how many equal parts?" The student mumbled inaudibly, and Phoebe said, "Into six equal parts, or you're going to divide the whole thing into three equal parts, aren't you? OK, choose the one you want to use [thirds or sixths]." She paused to warn the other students about talking, then told the girl to label each fractional part. The girl divided the square into six equal parts, making each of them one sixth. Phoebe asked her to mark only four of the sixths. Phoebe asked if there was anyone who knew an easier way to do that problem. After another comment to a student about his misbehavior, she called on another girl, who went up and erased the division between the last two sixths, and wrote in 1/3. Phoebe shouted at John, who had been the focus of most of her management comments that day.

Phoebe called a boy to the board to work the third problem, dividing the square into ninths. After dividing the square into thirds, he started subdividing each third, but didn't do it the way Phoebe wanted it done. At first she said "No, no, no," and told home to use the dots provided, then she told him how to draw the lines. When he tried to comply, she scolded him for not drawing the lines straight. She said, "I'm not going to bother letting you go up there, if you're not going to do it correctly." She asked the students how many parts they had. They said "nine," and Phoebe replied "Three parts, three nines in each part, don't we?" Actually, it was three <u>ninths</u> in each part.

After the student who went to the board showed 1/9 + 1/9 + 1/9 +1/3 + 1/3 instead of 1/9 + 1/9 + 1/9 + 2/3, a boy objected "But that's not <u>two</u> thirds!" Phoebe replied, "But we have one third and one third, don't we?" The student said something and Phoebe said, "One orange and one orange is two oranges? One third and one third are two thirds."

In the final part of this lesson, Phoebe asked students to turn to page 94 in their workbook and label the fractions in the nine squares on that page. These shapes were divided in more complicated ways than the previous ones. In some figures, the same fraction was represented in more than one way graphically. Again, Phoebe read the directions to the class, or paraphrased them, instead of asking students to read the directions themselves.

While they were working, Phoebe clarified that it was "the whole big shape" which was what they were calling "one."

Phoebe asked individual students to come up and label these squares on the overhead. For the first shape, divided into eight equal parts, she told the boy to label just one of the parts--"Because we know what the first one is, the rest are too." When John made another off-task comment, Phoebe responded "Excuse me John, you don't need to open your mouth to show how uninformed you are."

Phoebe pointed to the last shape on the page: "Look at the last one. Notice it is marked, drawn differently, but you still have eight equal parts, don't you? If you measured that and you measured it properly, then you'd see that."

I felt that this conclusion might not have been self-evident to the students, since four of the one-eighths were one shape, and the other four were a different shape.

After students completed labeling the fractions on the overhead, Phoebe told them to put their workbooks away and show her they were ready for recess. She announced that five students were to stay at their seats when the other students left for recess, and math was concluded for the day.

Phoebe's beliefs about motivation. Phoebe sometimes complained about how many students at Columbus didn't care about school or learning. She felt they liked school mostly as an opportunity to socialize, not to learn. In this teaching example, I observed many student behaviors that may have contributed to Phoebe's beliefs about her students' motivation (e.g., low engagement, off-task discussion, and groaning when the Math in Stride workbook was announced).

Phoebe's beliefs about learning. This teaching example again highlights Phoebe's emphasis on modeling, reinforcing correct answers, correction, and repetition. Also, as with the tangrams activity, this activity contained frustration on Phoebe's part that students couldn't just see the answer. There was almost a sense in which she sometimes seemed to think that the correct answer was transparent, which would explain why she often seemed puzzled that students didn't "get it." Phoebe also believed that using pictures was similar to using manipulatives. In this lesson, she felt that using manipulatives might help with students' understanding of geometry.

It is interesting that she had students share multiple correct ways of showing fractional parts of the whole. She never talked about multiple solutions to problems as part of her theory of learning. Perhaps, in this lesson, because there were multiple ways to be correct, modeling the multiple correct answers was important to her.

Phoebe's Goals and Beliefs

What Were Phoebe's Goals for Students?

When asked about the impact she hoped to have on students in mathematics, Phoebe replied first in terms of affective or motivational outcomes: "I hope they'll like it-- I hope they won't be afraid of it." Beyond that comment, the vast majority of her comments were about students' learning of mathematics.

Most important regarding learning for Phoebe was that students needed to learn a process or procedure for doing mathematics. Particularly early in the study, she felt she had accomplished something if students had learned the basics--"to add, subtract, multiply, and divide." The importance of learning computation was clear to Phoebe--she noted how students often got wrong answers because they lacked computational skills.

Tests scores measuring traditional outcomes were important at Columbus school because of a history at the school of low scores, and they were important to Phoebe. She had even called an inner-city school in Houston, Texas that was profiled on the television show Prime Time for having raised tests scores with mostly poor Black students. She had wanted to find out what program they were using.

Phoebe clearly and consistently stressed the importance of being able to do mathematics. I asked her if it was enough for students to be able to answer problems, even if they couldn't answer why questions about what they did. She answered that "It's enough for me," but then she concluded "But they also should be able to give you some 'why.'" However, her meaning for the "why" that they should understand in this situation was that they should be able to figure out "what process they did wrong."

Understanding never seemed to be the heavy emphasis of Phoebe's teaching, and she sometimes seemed skeptical about the need for students to understand mathematics. As noted earlier, she said her teaching was focused on "the procedure--this is the way you do it."

However, Phoebe spoke more about understanding later in the study, and believed that industry wanted more of the kind of students who could answer the "why" questions. By the end of the study, she was talking about the need for students "to have some concepts" in areas like geometry. Phoebe had concluded that students' understanding in geometry might provide a foundation that would make future learning easier.

Some recognition of the value of understanding also came in her reflection on her experience calling the school in Houston, to find out about what they were doing. She talked to the secretary at that school, who said, "[Our] kids can read, they may not know what they are reading but they can read." Phoebe said, "I thought uh oh! Then I said, that's the same feeling I have had about DISTAR before--where is the comprehension?"

Her modest but slowly growing emphasis on understanding seemed to parallel her own growing understanding of mathematics, as she said "I'm beginning, just now to figure out" some aspects of mathematics.

Nevertheless, Phoebe sometimes seemed unsure as to the value of some of the other goals associated with the reforms, such as estimation: "[I] don't know as how they'll use it--especially this group of children. Um, I don't know!"

However, by the last year of the study, she seemed to have changed her mind a bit on this as well, as she said "estimating is important."

Finally, Phoebe's goals were influenced by the students she had, as she noted that these students were "not going to be great mathematicians." She used this as an explanation for why she taught in a mechanical way, which she acknowledged, meant, "they don't have to think," but which she also thought was "defeating the purpose [of teaching]."

What Were Phoebe's Beliefs about Student Motivation?

My discussions with Phoebe revealed very little about her views of student motivation. She rarely mentioned factors that she believed would support students' liking of mathematics or desire to do it.

Recalling that students loved the tangrams, Phoebe wanted to get more mathematics games, because "They're fun, and they don't realize that they're learning." Noting that students learned through games "without really negative feedback on it," she concluded that using games would lead students to persist longer with the mathematics.

Phoebe believed that different students were sometimes harder to motivate. She explained that she "always had high expectations" of her Chapter I students, but was frustrated because "they [the students] don't have any expectations, [and] they don't care."

What Were Phoebe's Beliefs about Student Learning?

Phoebe was often puzzled about why students didn't learn something. The factors below were central aspects of Phoebe's beliefs about student learning.

The importance of doing the process. Phoebe stressed the role of experience in learning. In 1994, when students performed poorly with the then-new Math in Stride text, she believed their failure was due to students being unfamiliar with this approach. Three years earlier, when students seemed to be struggling with thinking about mathematics in 1991, she expressed surprise. She wondered why her students were struggling after having four years of experience with the Holt text, which she saw at that time as a program that emphasized thinking. Phoebe seemed to believed that repetition could even help make understanding automatic:

> So, if from the time they're in kindergarten it's "Why did this happen? What caused this? Why do you think this?" If that's a constant why, why, why, then when they get to this age level it will be such a rote thing that it won't suddenly blow them away.

When I asked Phoebe what it would take for her to learn how to teach in a way that had a greater impact in understanding, she answered that she needed experience with programs that emphasized understanding, concluding "a lot of it is just doing it yourself."

Manipulatives. During a sabbatical Phoebe took during the study, she studied an interdisciplinary approach. As a result of her experience, she concluded that she had to "get out of the lecture mode" and make learning more hands-on and active for students. However, Phoebe remained skeptical regarding the value of manipulatives for learning mathematics: "But I don't know that the hands-on has taught them a thing." She related her own experiences in math:

> I don't know, because I did fine with the abstract. I never had the manipulatives. But I've also I haven't always understood why. But, I never worried about it--it just was never important, because I never needed to know the "why."

She pointed to some of her own classroom experiences as suggesting that "it's gonna' take you all day" to solve certain problems using manipulatives. I asked if she thought using manipulatives was related to understanding: "I think they may be--but I'm not sure--I just know that some kids need to move things around." The few positive claims Phoebe made for the impact of manipulatives were largely limited to the area of geometry.

Relative to manipulative use, Phoebe had a vague sense that students' learning progresses from the concrete to the abstract. However, at times she suggested that perhaps by the time they reached her in fifth grade, they should be operating largely in the abstract mode. She pointed out that students would have to use "the abstract" in mathematics when they moved on to junior high school the following year.

Understanding. By the end of the study, Phoebe's comments did suggest that she valued understanding a bit more than in previous years. For the most part however, it was not clear how she thought such students' understanding developed.

She thought the use of manipulatives might aid understanding in geometry, and also believed that repeated, early exposure to "why" questions could make understanding "a rote thing."

Phoebe's view of teaching for understanding remained largely procedural. Describing a math test, which stressed understanding, she noted that students would "bomb right out, even though I walk 'em through it." "Walking students through it" was very important in her teaching, as evidenced by the way she prepared students for a test:

> I actually put the test on the overhead. And I sit there, now I read it to 'em. This is what they want you to do. I try to go through this whole process with them--so that they'll understand!

What was interesting about Phoebe's thinking about understanding was that she didn't seem to perceive her own practice as "marching students through procedures." That is, she at least scoffed at the idea of using the approach used in the Texas school which she investigated, because they were using the very traditional DISTAR program: "Well, I had a negative feeling too, because DISTAR is a very structured program. You know garbage in, garbage right back out again type thing."

Not knowing the extent of Phoebe's knowledge of the DISTAR approach, I can only wonder as to what she saw as the differences between that approach and her own. To me, Phoebe's highly structured approach, in which she moved students through problems, usually following the script in the textbook, was very similar to DISTAR.

Transparent facts. One of the more puzzling aspects of Phoebe's beliefs about student learning was the way in which she treated mathematical facts as transparent. She often demonstrated frustration with students not "getting it." She would repeat correct answers as if she believed that by gaining students' attention and repeating the answer, they would surely learn and understand. Given the convergent nature of the questions

Phoebe asked during such exchanges, students very often did get it right, perhaps because they were simply able to read her tone of voice and what her questions suggested regarding what the correct answer was.

Different students. Phoebe's beliefs about how students learned seemed to have been significantly influenced by the kind of students she taught. She said she taught in a mechanical way so students "don't have to think," noting that her students were not going to be great mathematicians:

> Well, you know, we know we're under the gun. But we can only do so much. I mean you can't get blood out of a turnip. And you can only do so much. I mean, if I wasn't doing anything with my kids, then I'd be at fault. But I can't, I can't assume that responsibility if they're not going to tune in to what I'm doing, and we've tried everything else.

Although Phoebe complained about their listening skills, and lack of interest in learning, she also expressed sympathy toward her students, who lived in one of the poorest and most crime-ridden sections of Southdale. "This group of children, they've got a lot of other things in their lives that are causing them grief." She attributed some of the difficulties that her students were having with thinking about math to these other stresses in their lives.

Telling, correction, and guidance from teachers. For Phoebe, the teacher played an important role in student learning. She noted the importance of clear communication by adults: "I think if you don't communicate the concept right, they're not gonna understand what they're doing." Her primary teaching strategies were modeling, asking convergent questions, telling the answer when none was forthcoming, emphatically stating correct answers, repeating correct answers students gave, and correcting incorrect answers.

Her teaching had been clearly informed by Thorndike's "law of effect." I could almost feel her stamping in the correct responses and stamping out the incorrect responses through reinforcement and corrections. I had rarely experienced such a strong form of this approach outside of special education. The fact that Phoebe's pre-service teacher training occurred in the mid-fifties makes it quite understandable that this approach was such a core element of her teaching practice.

Phoebe believed that the teacher had an active role in reform-oriented teaching. For example, when I asked if she thought students could learn simply from working with manipulatives or talking with each other, she replied that there "has to be some guidance" from the teacher.

New ways of teaching. Phoebe didn't believe that some elements of the reforms--such as use of overheads, calculators and writing about mathematics played a significant role in student learning. She didn't note any productive use for calculators, and didn't want students who didn't know their multiplication facts to use them:

> I'm not sure. You get the calculator answer, but then, you don't have a clue how to process it. If you're stuck without a calculator or the calculator breaks, how do you do it then? I don't think the world is ready for everybody to use a calculator.

Noting the high percentage of students at Columbus school with limited English proficiency, she said her students "hate to write," and for this reason, she didn't include any writing in her mathematics lessons, or use student portfolios.

Phoebe never mentioned the importance of discovery, writing, classroom discussion, or peer-peer learning. Perhaps her view of these aspects of the reforms was revealed by what she didn't say.

Phoebe's Own Motivation and Learning

Phoebe's goals for her own learning were very practical: "I take a class because I want something to get back to the classroom with. I don't want just a bunch of theory. I want something I can bring back and use in my classroom. That's what I want." In some ways, Phoebe's personal style seemed to conflict with the reform's emphasis on understanding, as she seemed more interested in doing than thinking. She wanted "something that will improve what I am doing in the classroom not just some philosophy up there--that's not my thing." Reflecting on her comment about some of the difficulties she'd had learning to use computers, I asked if she ever wanted to know the why of how something works:

> No, I don't care how that thing works. See, and that's part of the problem. Part of it's me too. I don't really care why some of these things, but this is what I have to do to make it work. Then I don't want to mess with why; I just want to do--you know, it's a very practical type thing. I'm not into a lot of philosophy, deep thinking--not gonna' do a lot of deep thinking about why. Because I'm, I want to keep going. I'm a project and product person.

I continued "So, if you were somebody who was very interested in why, do you think you'd teach math differently?" She replied "I probably would, because I would be more interested in that. [But] I'm a product person."

The sabbatical experience Phoebe had during the course of study, after more than thirty years of teaching, generated some real enthusiasm in her. She no longer seemed to carry the weariness of the daily battles with students, and she became very involved in thinking about teaching and learning. Notably, Phoebe's rejuvenation occurred in a year in which she had a great deal of time to read and pursue her own interests. She noted that she had "read practically all of the literature books that I picked up." I was surprised by the change in her demeanor, energy level, and engagement in reflection about her practice. I searched for an explanation for this transformation in her. She explained that she had the time to get materials, and read them and make phone calls. She added: "But see what am I doing? I'm doing something I want to do. I'm doing something I'm interested in, nobody forced me to do this."

After years of teaching in a very difficult setting, Phoebe still had some spark to learn and grow. Although her greatest excitement and learning centered on the social studies focus of her sabbatical, she reported that she was beginning to understand mathematics better, in part by using these newer mathematics programs. She laughing commented: "Yeah, if I stayed with it long enough, I might learn how to do it!"

I asked her if understanding would have a more central role for her if she had really played around with mathematics and had a firmer understanding of numbers. She answered "It might very well be." She explained that the students were having a real lack of understanding with the new ways of teaching, and this was a real problem "because the understanding, if you can understand it, then you can do it." Her response to my question was difficult to decipher. Phoebe's idea that understanding here may have meant nothing more than knowing the procedures for a new way of teaching and learning mathematics.

Effectiveness Depends on Teaching Methods

Given her teaching and her thinking about students' motivation and learning, what was the nature of Phoebe's efficacy beliefs? What were the relationships, if any, between the way she taught mathematics, including her attempts at more reform-oriented teaching, and her feelings of efficacy?

You Can Make a Difference

I asked Phoebe to think about her own mathematics teaching in answering second teacher efficacy question from the Rand studies: "If I really try hard, I can get through to even the most difficult or unmotivated students." She answered "2" (agree), and explained her answer:

> I think you can. Most of the kids enjoy math, unless it's just something they can't do--it's a concept they just have no clue about what they're doing. Most of them have fun, and if they're doing the manipulatives, they have fun with it. But if it's something they don't understand, of course it's not gonna' be fun.

Phoebe explained how lack of understanding can be overcome, and gave an example from that day. A few students didn't quite see something, she said something or a student said something, and suddenly the students who hadn't understood said, "Yeah, you know, I see this now." She sounded fairly efficacious as she explained further: "So, I think most kids--if they can visualize it and comprehend it, with extra work, they'll make it."

Phoebe thought she could impact all her students in math, although she said "it's harder, you have to work a little harder" with some of them. When asked about her actual impact on students in mathematics, Phoebe said, "I think I've got an impact," but quickly changed the discussion to her quilting and candlewicking projects, where she thought she had the most impact.

She sounded less efficacious when she noted that her students were "not going to be great mathematicians." Also, when reporting that they were "under the gun" from the principal to raise test scores, she had noted: "But we can only do so much. I mean, you can't get blood out of a turnip." She was quite negative as well regarding the lasting impact of students' experiences with mathematics in her classroom: "I don't know how much they're going to remember of what they should do in math (laughing) ugh!"

She summed up her impact on students in mathematics: "Some years it's good. Some years it's not. It just depends on how you call it."

Liking Mathematics

Although Phoebe didn't usually mention it as a goal, she said one of the ways she judged her impact on students in mathematics was "if they enjoy it, if math is kind of a fun time." However, I learned little about Phoebe's beliefs about motivation. I also learned little about what she thought made students like subjects, except her point above, that it's not fun if they can't do it.

On a day she said was "very typical," she said her math lesson went fine, but that it went slow, and said she was "bored, very bored." Student engagement and seemed mixed during these lessons, and they seemed to enjoy some lessons more than others. Phoebe often seemed to keep the majority of them doing what she wanted them to do. However, it seemed like many of the students' minds weren't into the work. She reported some lessons as being fun for students, but never explained her overall impact on students in mathematics in terms of their liking of it or motivation to do it.

They like "real math" better. Overall, Phoebe thought students liked the traditional math better, believing that it was "real math." She gave the example of how they enjoyed the traditional long division lesson described earlier: "They love doing what they did today."

Mixed effects with the new math. Phoebe thought students liked some of the reform-oriented mathematics practices, but not all.

She noted that students loved it when she used the overhead calculator, and liked playing with manipulatives. The clearest benefit for Phoebe of having students use manipulatives like Geoboards, as suggested in Math-in-Stride, was that it should make math fun for students. She thought some lessons were fun for students, such as the tangrams, and I also observed a lot of engagement and excitement during this activity.

Significantly though, Phoebe reported students not liking to use the Math-in-Stride workbook: "They hate this book." It was this math that they saw as not "real math." She said they referred to the Math in Stride workbook, which involved them in playing with materials, as "a baby book."

Phoebe didn't seem to enjoy herself when students played with manipulatives, and wasn't comfortable using the overhead--once saying she hated it. She reported enjoying some of the more reform-oriented activities involving graphing and geometry.

Learning Mathematics

Phoebe said far more about her perceived impact on students' learning of mathematics than she did regarding their liking of mathematics. I report her standards for judging student learning and her impact, then positive and negative indicators of her efficacy, and then relationships between her feelings of efficacy and traditional versus reformed teaching methods.

Her standards. Phoebe explained what standards she used for judging the sort of impact "If they're able to process, and do the assignment, then, I figure I've done a pretty good job of teaching that particular concept." She felt she had accomplished something if she could teach them to add, subtract, multiply, and divide. She didn't think that her students' ASAT scores (which were low) were "a good measure of kids," and said she would "throw the thing [ASAT] out." She said that the scores were hard to interpret, because some of her students didn't take those tests seriously and didn't try hard on them.

She noted that "I think what's a better measure is what can they do [are] portfolios, all these things." However, she almost never had students write about mathematics, and didn't have or collect any portfolio data that would provide clear evidence of student learning.

Positive indicators of efficacy. Phoebe sounded positive when explaining what she thought she could impact in terms of students' learning: "I think that they will come out of here definitely knowing more than they came in with, definitely knowing more, and they'll be able to process. They'll have, they'll have the skills that they need when they leave here."

Even Phoebe's successes helping students learn basic skills sometimes took great effort. She explained to me the long, laborious, procedure-oriented efforts that she and her aide went through to get students to learn their multiplication tables one year. They finally got eighteen of the students to pass the chapter test from chapter 1 of the mathematics text. However, by chapter two that year, she already sounded a bit helpless:

> When I gave chapter two, which was place value and decimals I got four [that passed] and I'm not sure I can deal with that one again. It's not worth my energy. So, I don't know! Some of them, they can do it if they can get rid of all the garbage in their brains.

Thus, some of Phoebe's success stories were accompanied by struggle for her, and failure for many students. She also was frustrated that these students were still struggling with the basics in fifth grade.

Sometimes students could perform, but their success required some prompting. For example, Phoebe described a group "that had just a disaster on their math paper." She went through some of the problems they had missed, and they couldn't answer at first why they had gotten problems wrong. However, once she started being more specific (i.e., asking whether they multiplied or subtracted wrong), then they could answer her: "See, then when I give them the words that they need, then they can tell me that what they did was wrong."

Felt efficacy was sometimes clearer, as when reflecting on one lesson in which she believed that the students had truly understood estimating and fractional parts of a whole, from using pattern blocks.

Tentative and negative indicators of efficacy. Phoebe often said, "I don't know" regarding whether she had helped students learn. Thus, after a lesson on the multiplication of decimals, she said: "I don't know. They had fun. Whether they have learned anything or not--I haven't got a clue." She thought some of them may have gotten the idea that there was a decimal point, but then seemed unsure--"Well at least they got the right answer. They put the decimal point in the right spot. I don't know, I don't know. [I'll] know better tomorrow."

Phoebe was often not sure whether students had learned, until they took a test, such as the chapter tests from the math textbook. Even for lessons that went "great," she often put off concluding that students had learned: "we'll see how they do on the test tomorrow."

Interviews also contained strong negative reports regarding learning. Phoebe described spending an hour on something, but when they got to the test: "some didn't have a clue what was happening still." One year, she pointed out to me that she had not gotten the whole class to pass any of the chapter tests. Sometimes, as with a test she described as "sad, very sad," failure came after prolonged effort:

> I gave them a test on those fractions, but they had to do something and then look at shapes and then tell why. They couldn't do it. They didn't have a clue why they were doing this. They'd done all this work and still didn't understand. They couldn't explain what they were doing.

When students didn't understand, why they didn't "get it" was often a mystery to Phoebe: "I have no idea. I don't. I don't explain it. They didn't understand. They didn't get what they should have gotten from this, what the publisher I'm sure was hoping they would get." Phoebe responded to students' lack of understanding by walking them through the process:

> I give them the math test then, and it's, it's a thinking process, and "Why did you do this?" and "Now, what would you do, next?" And they bomb right out. Because they don't understand how to do it. And even though I walk 'em through it. I actually put the test on the overhead. And I sit there, now I read it to 'em. This is what they want you to do. I try to go through this whole process with them--so that they'll understand!

Phoebe viewed herself as a process-product person. She taught the procedures, and students were supposed to produce the product--correct answers. When it didn't work, she was puzzled, because this was her model of learning.

Mixed messages regarding efficacy. Phoebe had mixed success with regard to who learned and what they learned. Phoebe said "some of the kids get it right away and some don't." Reflecting on a lesson, she explained that students catch on "once they process," and many had caught on, but others hadn't, like a girl who "was probably floating in the ozone layer someplace, and didn't have a clue what we were doing. I just bet my bottom dollar on it."

Partial success often came in the form of students learning procedures, but not gaining understanding. For example, Phoebe succeeded in getting students to do long division, but doubted they understood the reasons for the steps involved: "No, it's a rote thing. They just, they really couldn't tell you why probably. Now, they might make me out [to be] a liar, I don't know." The same pattern of outcomes appeared for the fractional parts of the whole lesson. When I asked Phoebe if she had reached her goals during the lesson, she said she had because students did the process: "Oh, I think so, yeah, they filled in the spaces." However, she went on to discuss more conceptual issues, and I asked if she thought had understood the concepts involved: "I don't think I was able to deal enough with it, so I want to go back and, and do that concept over. So, I don't know, we'll see."

Feeling effective with traditional methods. Phoebe felt more successful with traditional than with reform-oriented teaching. She felt classroom management was easier with a traditional program, and that she was more successful with respect to traditional learning outcomes. She said, "I think probably in procedures, I have more of an impact than I do in understanding, just because of the educational background that I have--that some of these things are new ideas [for me]." Phoebe expected she would be "very effective" if teaching mathematics was about procedures, and "in the 1970s, it was fine." She said that was enough to feel effective then, but was "probably not" enough to feel effective in the 1990s. She explained this changing meaning of efficacy: "In the 90s, they've got to have so much--you've got to have understanding. They've gotta' be able to transfer information--transfer knowledge, transfer procedures to other things."

Phoebe was beginning to see a changing landscape in learning, but wistfully recalled a math program she had used twenty years earlier. It was an individualized skills program, and the focus was computation, not understanding. Teaching math to her class and to one or two other classes, she felt very effective with this approach. Phoebe thought that if she could use that program today, she could have the impact she'd want to have.

Pulling out the rug--the first wave of reforms. Phoebe's first encounters with the reforms didn't yield feelings success for Phoebe or her students. Columbus changed from the Macmillan text they had used for years to a Holt text, which Phoebe thought was "much better on thinking." Phoebe's students had always been successful on the tests, but with the Holt program, "Kids who would normally pass the test in the old [program] weren't passing it and they were upset." She said the teachers from the gifted program, who had influenced the text adoption, had wanted a very challenging program: "Well, they got it! Because it just blew our kids away. Kids that had been successful in math all along, just got to fifth grade and it was like 'Whoa, wait a minute! What's going on here?'"

During the first year of this study, as Phoebe prepared students for the ASAT with "a crash course" in measurement and geometry, she expressed frustration again with the Holt text:

> We spend so much time on the fractions and we still didn't understand what we were doing. They still didn't know what they were doing even after I spent another

> week and a half out of the textbook on it. It was disgusting. Uh, they didn't know what they were doing with fractions.

Phoebe reported on other teachers' struggles with students not learning from the Holt text, and summed up the problem: "These kids can't think. This is a thinking-based program and they can't think." She said this was a new challenge for her students: "They had to think. They all wanted to work the problem, they didn't want to think."

Since the program at Columbus school had been heavily focused on basic skills prior to the reforms and the Holt text, this program marked a major shift for Phoebe as well: "So now we have gone from one extreme practically to another extreme."

Taking a break from the action. Phoebe took a sabbatical during the second year of the study, to plan an integrated social studies unit, as part of a program sponsored by the American Council of Learned Societies (ACLS). The learning experiences she had as part of the ACLS program stressed teaching through meaningful activity and integrated curriculum. Phoebe seemed very energized during this year. She said she was going to get out of the lecture mode and make learning more interactive and interdisciplinary the next year. Phoebe said she had known "for years" that this was the way to go, and was ready for the challenge: "I know what I'm going to have to do, and it's not going to be easy. It's going to be a lot of work, if I do it right." She said teaching this way would be hard, and she might have to return to teaching from the textbook from time to time. Phoebe discussed this new approach in relation to language arts and social studies, and never mentioned new ways of doing math, except when I asked about it.

There goes that rug again! Another new math program awaited Phoebe's return to Columbus, and with it, more challenges. During her absence, the upper grade teachers at Columbus had tried the "Math, a Way of Thinking" program, and decided it was based too much on manipulatives, and didn't have enough traditional content. Thus, they had chosen to switch programs again, to the "Math in Stride" series. This was supposed to be a happy medium between the Holt approach, and the more conceptually oriented and manipulatives-based Math, a Way of Thinking program. By now, Phoebe viewed the Holt text as being more traditional. However, simply changing programs raised issues regarding Phoebe's efficacy and feelings of efficacy. She believed that students' lack of familiarity with a new math series was one reason why they didn't get it during lessons.

Phoebe had some successes with the Math in Stride series, noting a successful activity on combinations of coins, and how Math in Stride led to some new understandings: "I do think they're understanding some things that the Holt didn't cover. Because we did so much estimating, they can estimate now they can round off. They know how to do that." However, the positive impact of this success on Phoebe may have been minimal, since she wasn't sure this kind of understanding was helpful: "[I] don't know as how they'll use it--especially this group of children."

Phoebe seemed to have more struggles than successes with this approach. She described a Math in Stride lesson on tangrams that wasn't effective, and how that led her to turn to the Math, a Way of Thinking series to teach that unit. Also, despite all her efforts--"I've been doing everything but telling them what to write down," she said her students continued to struggle with thinking and problem solving. Describing a lesson involving frequency charts and the corresponding test, she said students just "didn't transfer the information, and the knowledge, they didn't transfer the knowledge. The tests have been absolutely abominable."

Often she was unsure about what students had learned: "The kids, they seem to understand, and that's what they're supposed to be getting--is this comprehension." However, a disclaimer followed immediately, "But let me tell you--I dunno. We'll see when it comes down to the test. I dunno, I guess it's new--it's frustrating."

Why do it that way? Phoebe struggled in part with the Math in Stride version of reform-oriented mathematics teaching because she was sometimes simply baffled by why the publishers taught or represented math in certain ways. Visibly exasperated, and puzzled by the Math in Stride procedures for teaching division of fractions, she explained the advantages of the traditional approach: "It's real simple to divide. You turn the second one upside down and multiply. So, you have twelve over twelve right away. It's easier to tell them this is what you do."

Moreover, Phoebe was often skeptical about whether or not the new approach would work. Thus, she didn't try a Math in Stride lesson on multi-digit multiplication, which she described for me:

> And you write the two times the ten and there's the twenty. Then you go ten times seven and you get seventy, and then ten times ten. Sounds like an awfully complicated way of doing it to me. Does it add meaning and understanding? It doesn't. I don't know. Because of course I didn't do it that way.

Thinking this approach "would do nothing but confuse them," Phoebe supported her skepticism by describing the results of her earlier attempt at teaching multiplication this way: "You know, all this was total confusion to them." Similarly, after struggling for a week and a half to teach one topic in the new way, she concluded that the Math in Stride ways of teaching may not aid comprehension, but "might confuse them, because I think it's confusing to me."

Finally, Phoebe was concerned that the layout of parts of the Math in Stride textbook made it possible for students to take shortcuts, and get the right answer, without understanding what they were doing. During an activity on equivalent fractions, she saw students counting spaces on a chart to get the right answer, without really understanding how they would "compute" the correct answer. It was interesting that she objected to a procedural path to correct answers here, but not elsewhere, although perhaps that was because this text was supposedly aimed at fostering understanding.

Overall, Phoebe wasn't sure if the Math in Stride was as strong as it should be in helping with problem solving or "why" questions, and thought parts of the Math in Stride program were beneficial, while the rest was useless.

Mixing methods for maximum impact. Phoebe didn't believe the reform-oriented approach addressed computation well, nor that the traditional methods addressed understanding well. Thus, she alternated between use of her newer and older texts so she could have an impact on both computation and understanding. She pointed out that all the other fifth-grade teachers did the same.

In the first year of the study, Phoebe abandoned the Holt text and went back to the more familiar and traditional Macmillan text to get students ready for the ASAT. Three years later, she dropped all attempts to teach from the Math in Stride text, and went back to teaching from the Holt text in order to get students ready for the ASAT. At the time, the Math in Stride program had students doing interesting activities representing fractions in strips, however:

> I knew the ASAT test was coming up, and they were finding patterns with them, but they didn't know what they were doing. They could not take and change two fractions with uncommon denominators--to add [them]. They didn't have a process.

Phoebe emphasized that not only for the ASAT, but also for sixth and seventh grades, students needed to have "learned a process" so that when they "get handed a Holt book," they can "function with a paper and a pencil." She felt that Math in Stride was "too much play and hands on--not enough just solve," and by using Holt as well, she hadn't given up her effectiveness in teaching students computation. At the end of the study, Phoebe estimated that forty percent of her lessons came from Math in Stride, and sixty percent came from Holt.

Unfortunately, even this mix of approaches didn't always work for her. She taught a unit from the Holt text, but gave the students the chapter test on that content from the Math in Stride book. Despite this mixing of approaches, or perhaps partly because of it, Phoebe ended up with students who hadn't seemed to learn the math at hand--"And I thought by the time we finished this they were going to ace that test. Oh, it was gross, just gross. So discouraging."

While Phoebe often viewed the math reforms as being represented by the new mathematics texts, she also understood that using new teaching tools was part of what the reforms were about. I turn next to Phoebe's experiences with some of these teaching tools.

Manipulatives. Phoebe thought that using manipulatives to teach was a central component of the reforms, but it was unclear how using manipulatives related to her feelings of efficacy.

Sometimes using manipulatives seemed associated with student learning. Phoebe gave one example of students learning from pattern blocks: "they do understand, though--looking at those pattern blocks." Similarly, she thought a tangrams activity had helped students' thinking. Some of her positive comments were hypothetical, as when she thought students could come to understand volume and area by playing with cubes, or could understand what numbers stand for. In these examples, she stressed that the understanding gained would be good for students who only knew procedures, but she emphasized that they still needed to know procedures and math facts.

Phoebe sometimes sounded more negative regarding manipulatives: "But I don't know that the hands-on has taught them a thing." Similarly, she wasn't sure what students had learned from a Geoboards activity, or how it related to the abstract aspects of mathematics.

On another occasion, Phoebe said she wasn't sure what students would get from manipulatives, but said it was some concrete manipulation, and that they can get quite a bit from it, but then said she wasn't sure how much some of them would "process" it.

Phoebe became a little more comfortable with manipulatives over time, and felt she could give up some coverage of topics if students were "getting the why" from spending time doing the hands-on activities. However, she worried that it could take all day to learn something using manipulatives, and students couldn't just play with the manipulatives for them to be effective. Phoebe believed that students had to make some connections and really process--and that guidance from the teacher was necessary for students to really learn in this way.

Finally, using manipulatives often led to students working at different paces through activities, which created management problems for Phoebe, and made teaching harder.

Calculators. Phoebe expressed some skepticism about calculator use and whether calculators helped students learn or changed what they needed to know. However, her views on this seemed to be changing. In the last year of the study, she noted how "if you have your calculator, it'll do that long division for you." She said this meant you didn't need the knowledge of long division that comes from "practicing reams and reams of" problems. She said that in that case, a basic understanding of the process was sufficient. Despite this change in goals, she never reported any ways in which using calculators aided students' learning.

Writing about mathematics. Phoebe felt that the reform-oriented programs should result in student ability to write about mathematics. Having students write about math had led to Phoebe's discovery that although she thought her students understood something, they didn't. This failure on their part was "negative feedback" for her. She initially concluded that students' inability to write about math indicated a weakness of the Math in Stride program, but then wondered if it simply resulted from too little experience writing, or the fact that English was the second language for most of her students.

The overhead projector. Phoebe believed that the overhead was also an important aspect of the reforms, but didn't find it very helpful. Although she said using it allowed her to "keep my eye on most of the class," she was frustrated by how little she could write on an overhead. She said her overhead had "gathered dust" for years, and she wouldn't have ever used it if it were not for the pain in her hips and knees.

Phoebe worried about the effects of using the overhead on student learning:

> If I have it on the overhead and I'm sitting there, doing it, then, what are they getting? If I'm putting the answers on the overhead, are they processing anything? Are they getting the information or are they just doing it?

I was puzzled by this quote, since I thought her teaching when using the blackboard was very similar to her teaching when using the overhead. However, perhaps Phoebe was starting to think about how just doing problems didn't necessarily lead to understanding.

Phoebe saw one potential benefit of the overhead. She believed if she had appropriate transparencies for math activities, then that would give students something to focus on, and would help her manage the class and keep all her students working at the same pace.

How do you know they're learning? Overall, a problem for Phoebe with using reform-oriented practices, specifically Math in Stride, was that she had no means for assessing student learning: "I can't assess this, unless I have them write about it and then, I go to have 'em write about it and they can't do it." She noted: "I don't feel comfortable with the program and where they're going and what they've got, and that kind of thing. I just don't know what the understanding and learning is. I dunno." I asked her how this made her feel about her effectiveness as a teacher:

> If the kids can't, can't justify what they've done, or they can't tell you what they've done--then, you begin to wonder whether you did a good job of teaching that concept or not. If they can't--if they can't relate it to something, and make it meaningful.

Phoebe said this experience made her feel less secure about her impact as a teacher, and that having a tool to show what students were learning from reformed practices would be very helpful.

Phoebe acknowledged that her lack of familiarity with the reformed approach to teaching may have affected her ability to gauge student learning. Thus, she said regarding the activity on fractional parts of the whole: "So, I think they've got that concept--they're probably doing better than I think they're doing--because its not the traditional way I'm used to doing it."

Unfortunately, test scores weren't easy interpret for judging one's effectiveness, because the new tests were both different and harder than the old ones. Phoebe noted how "every year we get the new test, the test scores drop." Phoebe had concluded that the Math in Stride program was less effective than the Holt text for helping students perform on the ASAT, and in turn, Holt was less effective than the Macmillan text. The new CLAS test didn't provide clear evidence regarding the effectiveness of reformed practices. On one occasion, Phoebe attributed Columbus' fairly good scores on the CLAS to the school's manipulative-based program, but at another time said she didn't know what the scores meant. Since most teachers at the school were using a mix of traditional and reformed practices, and since scores were not reported classroom-by-classroom, Phoebe didn't know how to interpret the scores.

Lacking a clear tool to assess the effectiveness of reform-oriented teaching, Phoebe's was uncertain about its effectiveness: "I think that this is probably a better way. But for all kids, that's not necessarily the best way to do it. Because everybody learns different, so I don't know."

Social and Individual Factors in the Case of Phoebe

One of my initial guiding questions focused on understanding relationships between efficacy beliefs and reformed teaching in light of the multiple contexts in which these teachers carry on their work. To better address that question, we examine next the social factors that influenced Phoebe, and then the individuals factors which were salient in this case.

Social Influences

The push for new teaching and learning. Phoebe attributed some of the state-level reform effort to the needs of industry: "I've heard that industry wants people who can think, and they don't, they're not getting them now, and that's true. I can understand that."

Apparently, the mathematics education reform movement had trickled down to Peggy only through textbook adoptions, and the school-wide pressure to use manipulatives. When I asked if she knew what the NCTM Standards were, she said, "what's that?" and "[I] haven't got a clue!" She also had little awareness of the state mathematics framework: "No, I am not familiar with the math state framework. I may have a copy of it, somewhere--but I'm not sure where [laughed]. There may be one, over in there someplace."

Phoebe's vision of the reforms was deeply tied to the use of manipulatives. I asked if her tangrams lesson was consistent with the reforms. She said it was because "it's manipulating, it's comparing, they can see it. It's right there." Then she said that if her principal and others pushing the reforms were to judge the lesson, they would approve. I asked, "If you're using the manipulatives, then, you're doing the right thing?" She replied "I think so. I, I hope so!" She explained: "I think they figure if we do the manipulatives, they'll understand."

Phoebe also thought the CLAS test was definitely going to affect how teachers taught, moving them towards "teaching for understanding, and writing about it." She explained why the test would affect teachers' practice: "It's like any other test that they give around here--pressure's put on, [and] your kids have to perform."

Teaching resources. Phoebe sometimes did and sometimes didn't have the materials she needed, and she felt the reformed texts didn't give the teacher enough guidance on how to teach.

Phoebe described Columbus school as having "gobs of money." The manipulatives and other resources the school purchased made it possible for Phoebe to use manipulatives at times, which she said helped her to have more of an impact in mathematics. Phoebe also had reform-oriented materials she could have used, but didn't, such as a calculator program that was still in her closet, unopened.

Despite this apparent wealth of resources, Phoebe didn't always have the manipulatives that went with the lessons. She also had to provide her own materials at times. Phoebe stopped using Math in Stride at one point because it required her to copy a lot of activity sheets, and teachers only got three extra reams of copy paper at their school: "That's not enough copy paper to spit at." She didn't want to spend her own money on copy paper, and got frustrated about the money she invested in making the materials for the activities in the Math in Stride series: "I spent about twenty dollars on macaroni and stuff like that. My money! Not the school! My money! And used it for one or two lessons, and [got] very frustrated with the whole process and said, 'Forget it.'" Phoebe said "It was just one more thing they were expecting us to pay for," and she cited this as a major obstacle to using certain lessons from Math in Stride. A year later, at least the issue of copy paper got resolved. The principal's husband was the budget director for the school district, and that year, they got all the free recycled paper that they could use in class. Phoebe described this as "wonderful" and noted how it changed what she could do. She had run off a copy of the entire tangrams workbook for each of her students (3500 copies), and had also used that extra paper for copying the worksheets that went with the Grandfather Tang book.

While Phoebe said, "The school has provided so much," she noted one thing that would improve her effectiveness in math: "math games would be a big help." She didn't have any, and thought that could be a good way for students to learn math. She also wanted more overheads to go with the lessons, to help her with management during activities involving manipulatives.

Another significant issue was the guidance Phoebe got from the textbook series. Phoebe said the Math in Stride teachers' edition was "worthless." It didn't give enough direction in how to conduct the lesson, and didn't connect the activity to the mathematical concepts involved. Phoebe felt the guide also didn't give the teacher help on how to connect concepts from the lesson to other mathematical concepts. She sized up the teachers' edition: "This is nothing--this is philosophy." In contrast, Phoebe noted that the teacher's edition for the Math, A Way of Thinking program was more useful, "because it's scripted for you. I mean, it tells you what to say, and it tells you what the kids should answer." This is a significant issue. Most would argue that teaching for understanding cannot be scripted. Nevertheless, what kinds of things should a teacher like Phoebe say during reform-oriented teaching? If she couldn't get that information from the teachers' edition, from where was she supposed to get it? Phoebe pointed out "It's a new program and I'm not sure what I'm doing." She thought that it was harder to teach this way, and said "nobody has a good handle on it." Phoebe seemed to be really trying, but wanted more help in teaching this way.

Getting teaching ideas for mathematics was important, as Phoebe didn't portray herself as able to create her own ideas for teaching math. Asked what teaching tool she would want to get first if she was going to teach mathematics on a deserted island, she immediately answered "An idea book." She explained "It would just give the ideas of what to do--'cause after awhile, you run out."

Lack of models of reform-oriented teaching. Phoebe said there was no one she saw as really doing a terrific job teaching math this new way. Although there was a mathematics "mentor teacher" at Columbus, Phoebe wasn't sure how good she was, and sounded unimpressed. She said the mentor teacher was in the main building, which was quite some distance from Phoebe's room, so it was hard to talk with her. Finally, Phoebe noted "and she thinks she's better than the rest of us so I just steer clear." The one person who Phoebe thought "comes the closest to doing these things" was Jane, a teacher whose class was across from Phoebe's. Unfortunately, Jane was struggling some too with reformed mathematics teaching: "She'll get two or three that get the concept and do the writing, but they [the rest] didn't get it." Jane, who Phoebe looked up to as a teacher, indicated some disgust and disappointment when I asked her about the Math in Stride program. Jane also agreed that there wasn't really enough there for teachers to teach with. Finally, Phoebe sometimes discounted Jane's successes, because Jane was teaching a gifted class, and Phoebe wasn't.

Staff development. Phoebe hadn't gotten much from staff development that helped her teach math, but wanted to get more. Interestingly, one of the few clear stories she recalled from staff development experiences was of a professor who she thought was on the state board of education, and who emphasized that students "have got to memorize their basic facts!"

Phoebe explained how important staff development was: "Until you have actually participated in and attended some form of a workshop, you don't tend to incorporate those things." Phoebe said inservice experiences made her more productive with teaching tools, and said that lack of such an experience was why she hadn't used the calculator program she had in her closet. She had signed up for a session at the upcoming district math conference on using the program: "Hopefully I will get it [the session] because then, then that [program] will become useful to me. Otherwise it's an expensive piece of book work with all these calculator lessons on it and I haven't got a clue how to use." Phoebe also hoped for some experience with mathematics programs that "make connections." She also wanted more time to make materials for teaching math. While Columbus had one in-service day to make materials, Phoebe said much, much more time was needed.

Interestingly, Phoebe said that the good in-services were those where you took a material you didn't know how to use "and you get hands-on experience with that material." She described the boring in-services as those "when you sit and listen to somebody."

Parents. Phoebe didn't seem to get any help from parents in supporting her mathematics teaching. She had little contact with parents, said many of them were apathetic, and she worried that many of them didn't see education as important. She cited the "lack of support at home, lack of ability on parents' part" as factors that interfered with the impact she could have in mathematics. Phoebe noted how some of the parents "give you wonderful lip service," but don't supervise their children, nor make sure they get their work done. Citing an example of one boy's father, who was illiterate, Phoebe recognized how it was difficult for such parents to be helpful with homework or to provide supervision.

Time. A central issue was that Phoebe needed time to learn the new way of teaching. Columbus School had changed texts several times, and Phoebe's lack of familiarity with the new textbook was a significant factor in her teaching effectiveness. Asked if she felt as effective in helping students learn with Math in Stride as with Holt, she answered: "No, and it's because I'm just not familiar with it." She said that each time she taught a lesson, it got easier. Phoebe sounded optimistic that she would be more effective with Math in Stride program in time: "Yeah, give me another year, give me a chance to get my feet wet with it." She compared her increasing effectiveness with the new math program to the strong emphasis on the social studies CLAS test on maps. With maps, her students hadn't done as well with as she hoped, but she felt optimistic "I'll do a better job on maps next year than I did this year."

Phoebe seemed like a very hard worker, and her teaching was well organized, but it sounded like she was always playing catch-up with reforms: "About the time I figured out really how to be effective on the place value chart, they changed programs and went to something else. And so, it's a continual change, constantly trying to re-invent the wheel."

The time-intensive nature of reformed teaching was an obstacle for Phoebe. She drew an analogy between the reformed approaches to teaching math and science, saying both took lots of preparation, and time. I asked her if she thought the people who designed the science program had a good idea about what students should be learning: "Oh they do! They know what they want them to do--but they have no clue what impact a program like this has on a classroom teacher."

Adult teaming and collaboration. Phoebe was convinced that teaming was necessary for success with reform-oriented mathematics teaching, especially if manipulatives were used a great deal: "If you're gonna' survive, you have absolutely got to team." She teamed for several years with a teacher who had retired by the time of this study, and they had each specialized in certain subjects. She thought this approach increased the impact she had on students, and would make it easier to use the reformed methods: "You are a much more effective person, because then you become an expert in something, and it's just all right there." Phoebe had tried to get other teachers to team with her in recent years, but to no avail.

Student ability and characteristics. Phoebe talked a great deal about what her students were like and how that affected what she could accomplish in her teaching. In the first year of the study, she had a "regular" fifth grade classroom, which seemed to her (and to me) to include many students with very challenging behaviors. She described her students the first year as low-ability, as not focused on learning, and as having "a lot of other things in their lives that are causing them grief." She was sympathetic to these students' difficult life circumstances. She noted that one boy "can't focus on anything he's so angry." Because these students had low ability, and Phoebe thought they would not be "great mathematicians," she taught in a mechanical way. Even teaching basic skills was a challenge: "I mean normally in the past I can forget the abstract and just go with the mechanical because that is the way you do it, but these kids don't even process that."

In the last two years, Phoebe had a "transitional" classroom, containing students for whom English was their second language, but who were making the transition to a "regular" classroom. Most of these students were Hispanic. She described these students in this way: "They love to come to school, but, they don't come to learn. They come to socialize." She thought "it would make all the difference in the world" for her success in teaching in a more reform-oriented way if she had students who loved school and came to learn. The talkativeness of these students undermined Phoebe's feelings of effectiveness in teaching mathematics: "This year, I'm not feeling really effective at all with this crew, and I think part of it is, I don't feel that, that they've got the class control."

Phoebe said these students' difficulties with the English language made them struggle with writing, and so she didn't ask them write about mathematics. She also thought their level of English proficiency made it harder for them to succeed with word problems.

Phoebe repeatedly noted that her students' ability level limited the effect she could have. She said that Jane could use the Math in Stride program "at a different level," and could cover more material than Phoebe could, because Jane had gifted students. The next year, Phoebe pointed out that Jane was making slower progress with her new class, because she no longer had gifted students.

Finally, Phoebe cited other student characteristics that she felt affected her impact. Her students' inability to work together, and that they "definitely have a procedure in mind," and don't think about the "whys" were other student characteristics impeding use of reformed practices. Also, it was hard for Phoebe to get verification that her students had learned, since her students sometimes didn't even try on the tests which she relied on to gauge learning.

Phoebe Behind the Scenes

A process-product view of the world. Phoebe clearly favored a practical, let's-get-it-done approach. She wanted to learn the process she needed to do to get the product she wanted. Even understanding was viewed as a process that could become automatic with enough repetition. She didn't think there were many "why questions in mathematics even she thought the "whys" meant knowing that you got a wrong answer because you did certain procedures wrong: "That's the answer to the 'why?'"

She was compliant. It is important to remember that despite Phoebe's procedurally oriented background and views, she was a dutiful follower. Despite disliking the Math in Stride workbooks, and feeling that the students disliked them, she used them, in part because the school had spent so much money on them. She also explained that she tended to do things the principal expected her to do, because "she's my boss." Phoebe said her compliance was a function of the generation in which she grew up.

However, compliance alone wasn't always enough to make reformed teaching and learning happen. While Phoebe agreed that the need of industry for more "people who can think" would motivate her to teach somewhat differently, to engage more in why questions and thinking about math, she didn't know how to make that happen. She said some teachers would say, "I have my kids thinking all the time," and I used to think that, too, but no, I don't have my kids thinking, because they can't process."

Her feelings of efficacy with other subjects. Phoebe gave different accounts at different times of her relative efficacy in different subjects. Sometimes math was in the middle, sometimes higher.

However, Phoebe struggled with helping students understand subject matter. This was true even in social studies, although Phoebe loved social studies and was knowledgeable about the state social studies framework. In fact, she said that her immersion in social studies was why she didn't know more about the state frameworks in math. However, Phoebe said her students didn't really like social studies, and often didn't understand it. She described doing an interactive social studies lesson and having students write about it:

> I had 'em write about what they'd learned--they didn't learn anything. They didn't know anything. They--they could not take themselves from present-time, today, and put themselves back in time as if they were a pilgrim. They couldn't do that. They couldn't make that transfer, so when we got through, I figured--they didn't know any more now than they did before we started the thing!

While she said, "they had fun," at the end she said some of them still didn't even know who the pilgrims were. Phoebe seemed astounded by this, since she said she knew the primary teachers "all make these little hats, you know, and the Indian things at Thanksgiving." I asked her how she could explain this: "I can't. I cannot explain it. Because I know they've been doing this kind of thing. Every Thanksgiving--they do something. But they just, they just don't understand." I asked: "So you can do pilgrims a lot, but still not understand pilgrims?" Phoebe agreed. I wasn't sure she understood my broader point that doing alone doesn't necessarily ever create understanding. What students did get down pat in this experience was a phrase. Phoebe said they knew to say "religious freedom" if asked why the pilgrims came to America: "They got that down."

Phoebe felt most effective in doing the quilting and candlewicking projects she did annually with students:

> What I think the impact is gonna' be with these kids is that they're gonna' remember some of the other things that they've done with me. They're going to remember the candlewicking they've done with me. They're gonna' remember the quilts they've made with me.

Phoebe noted that students loved the candlewicking, and said, "it's a skill they never will forget. They'll never forget it." Speaking of one boy's reaction to the quilts, a boy who was otherwise somewhat difficult in class, she noted "I mean [he] is so excited he can hardly stand it. He is just beside himself. And some of them have really good skills." Phoebe noted how students from other classes had asked if they could do the quilting too. Also, these projects were what students from past years had told Phoebe they remembered from her class.

Her personal interpretations. Phoebe described herself as "an optimist--the cup is half-full, not half-empty." She didn't worry before lessons about whether students were going to learn: "I feel that they're gonna get something, yes." However, she noted "It's afterwards when I discover that they haven't [learned] that I start worrying [laughing]."

If lessons didn't go well, she didn't get down on herself: "I always know tomorrow's another day." She said she often just didn't repeat activities that didn't go well--"Forget this! We won't do this one, again!" She said she was particularly likely to give up after one try on those activities that took a lot of preparation, but which didn't lead to students getting "the concepts that you wanted to get across":

> Because if it doesn't work, and you put a lot of time into the preparation on it and all that, and it doesn't work, well, forget that noise, I won't--just won't do that again, because it's a lot of work.

She didn't report being self-conscious about her teaching performance. When I asked if she thought often about "how am I doing" while teaching, she said she tended to think about whether she was being clear, and whether students were understanding her and the concepts. She said she compared herself with Jane, the gifted teacher, and thought Jane did Math in Stride better than she did and used the overhead better. Phoebe said she felt a little inadequate by comparison at times, but it didn't bother her.

She said she hadn't experienced much in the way of getting into mathematics with the students that she didn't understand, but then laughed, and said "I haven't come across that, but then, I'm pretty selective as to what we do, too." She said that if this occurred "I very well might feel uncomfortable, until I've figured [it] out," and noted how she would go to Jane for help on something like that.

If students didn't understand a lesson, Phoebe would just try harder next time:

> So, I may look at the test questions again and decide whether, um, there is enough why in there and if not, I may go ahead and decide to put some more why in there. I think I will, probably try that again next year, and you know see what happens. All I can do, like I tell the kids, the best job you can do. Do the best you can.

A Normative Look at Phoebe's Teaching

Of the three teachers, Phoebe's practice was the least reform-oriented. Most significantly, her view of understanding was that of instrumental understanding, rather than of conceptual understanding, and this colored her practice deeply. Her instrumental view of understanding was reflected in her belief that even understanding could be made "a rote thing." Her heavy emphasis was on doing mathematics, rather than on attending to and developing students' understandings. While Phoebe wasn't even aware of all the elements of the reforms, she didn't believe that what the reforms describe as mathematical power was appropriate or necessary for all students. Believing her students wouldn't be great mathematicians, she made math very mechanical. This is clearly in conflict with the reforms, which emphasize the development of mathematical power for all students (California Department of Education, 1992; National Research Council, 1990). Finally, Phoebe made only modest use of manipulatives, didn't use calculators or computers in her teaching, didn't emphasize either problem solving or real-life applications of mathematics, and stressed correct answers rather than mathematical reasoning.

Phoebe had begun to use a few of the practices associated with the reforms, such as manipulatives, but her use of these was still quite traditional. Overall, Phoebe's teaching practice was a long way from being reform-oriented, and she was a long way from understanding what the reforms were about, let alone accepting them, and enacting the practices they recommend.

Chapter Five

CROSS-CASE ANALYSIS

Introduction

What could have happened in these three cases? Growing belief in the positive impact of reformed practices (positive outcome expectancies) could have combined with the teachers' growing confidence in their ability to teach in reformed ways (positive self-efficacy beliefs), and increasing experimentation with reform-oriented mathematics practice. Changing practices and changing beliefs would have supported each other reciprocally. Movement towards more reform-oriented practices would have been gradual, as we know that new beliefs and knowledge do not simply replace the old, but rather, there is a gradual process of construction, and reconstruction (Smith et al., 1991). Research into educational innovations suggests that successful reforms take at least three to five years. However, the change process for these teachers might have taken well more than five years, since California was asking that they reform their teaching in multiple areas simultaneously. However, a catalyst in this positive recursive cycle of change would have been the assessment tools that teachers would have been armed with. These would have allowed them to keep track of their own gradual progress towards reform-oriented teaching, and their students' progress towards mathematical power. Mathematics experts and commercial publishers would have supplied teachers with the conceptual and material tools needed to continue this progress, and school districts would have significantly increased time for staff development, to help the process along. As these teachers' ability and faith grew, they would have gradually brought parents along too, helping them understand the reasons for the reforms, and the effectiveness of its methods. In the end, all three of these teachers would have felt that they could have a significant positive impact on all students' learning of mathematics and their attitudes towards it, by using the teaching practices associated with the reforms.

I turn next to review the cases of Molly, Peggy, and Phoebe. I examine why this tale of the reforms is close to what happened in Molly's case, but little resembles what happened for Peggy and Phoebe. Each story provides a back-and-forth tale of the relationships between practices and beliefs. Following these case summaries, I examine the four major issues that seemed most significant in my reflection on and analysis of these cases.

Synopses of the Cases

The Case of Molly McCarthy

The motivation story. Molly thought that liking mathematics was terribly important, and believed that liking or disliking mathematics was a function of how it was taught. Her experiences with mathematics led her to see math as fun and puzzle-like, and she taught it that way, expecting students to like it. She began lessons by eliciting children's interest with games or activities, or by connecting math problems to their lives. Her belief that students naturally liked games was supported by students' deep engagement in problem solving, and their genuine excitement when they figured out problems.

From her experiences as a teacher, and with her own children being turned off to mathematics, Molly had come to believe that variety was crucial for students' attitudes towards a topic. Therefore, she kept variety in her choice of games and activities, and alternated between different types of activities and between different participation formats. Believing that you keep students' interest when they have to alternate between looking up and writing or doing something at their desk, her lessons often shifted back and forth between a focus on mathematical representations on the overhead, and a focus on the students' writing or work at their desks. She believed that the lack of variety in the traditional drill-based EXCEL program was "a way to make students hate mathematics."

Molly believed pacing was crucial to maintaining interest, and kept a brisk pace in her teaching, to keep everyone involved. She believed that students would get bored during extended discourse, perhaps based on her experiences with shorter discussions, and she didn't use this element of reform-oriented teaching.

Believing that challenge and struggle could be beneficial, but that interest waned when students "got stuck," she gave enough assistance so that they didn't get frustrated or bogged down.

Molly said her students wouldn't say they didn't want to do math, they always enjoyed mathematics, and many cited it as a favorite subject. This was consistent with my observation that her students seemed highly intrinsically motivated to do mathematics. All this experience provided support for her very high personal mathematics teaching efficacy self-rating, which she explained initially in terms of her impact on students' liking of mathematics.

Molly's account of motivation portrayed a cycle of positive interdependence between Molly and her students--each "getting" motivation from the other. She taught in a way students found interesting, she got energy from their positive responses, and she reinvested that energy into her teaching. Commercial suppliers fed into this cycle. Molly didn't consider herself creative, so she in turn relied on commercial suppliers, needing games and tools like the overhead to make this kind of teaching and learning possible. Thus she explained why the overhead would be the first tool she would want to get if teaching on a deserted island: "I don't know what I'd do without the overhead, because you keep kids' interest with that."

Molly's own motivation to teach this way was self-regulated. It came from her own deep beliefs--based on her experience--that this was the most effective and interesting way to teach. She sustained her own interest and kept teaching fun by regularly trying out new games and activities, again highlighting her interdependence with commercial suppliers. By gathering evidence of students' emotional and motivational responses to mathematics, she gathered the positive feedback that energized her.

Students also were impressive in their self-regulation, as they worked extremely diligently on mathematics and other subjects, even while unsupervised by Molly. Not surprisingly, students didn't simply "have" this ability when they first came to her, but it was something she had helped to develop in them.

The learning story. Not considering computation to be the centerpiece of mathematics, Molly built a practice focused on problem solving, communication, and understanding. She did this partly by having computation dealt with early in the year as homework. She believed students' learning went from the concrete, through a stage of connecting the concrete to the abstract, and then on to operations using just the abstract terms and symbols of mathematics. She also followed this sequence in her practice. Having students work with manipulatives as a step in building concepts, she then made clear the connection between the manipulatives and mathematical language and concepts. Having paid special attention to the language of mathematics paid off, as she found her students to be very proficient with mathematical terminology by the end of the year.

Believing that traditional practices didn't build brain capacity and intelligence, much of Molly's practice centered on the problem-solving activities that she thought did build intelligence. Whether or not this stimulated brain growth, she helped students learn an array of problem-solving strategies--even those students from traditional classes who began the year insisting that there was only one way to solve problems. Noting how students could do more "mind-stretching," higher-level math problems if you simply allowed them to use the calculator for the computation part of problems, she often took just this approach. Thus she proved her belief that students did not have to learn "the basics" first, and engaged students in tasks in their "zone of proximal development" (Vygotsky, 1978). Molly considered struggle and discovery to be important for learning and remembering, and gave students time for this. Students often justified Molly's belief that they could discover the answer if they persisted. Discovery was guided, as she modeled, told, and gave students clues. The resulting learning was often very much a co-construction, with students getting part of the way towards the answer, Molly giving a hint, and students then figuring out the rest. Students and Molly both contributed to student learning as both students and Molly modeled problem-solving processes, usually on the overhead. Molly believed in learning by doing, and through the experience of presenting their ideas in front of the rest of the class, students had become very accustomed to presenting their ideas and quite skilled at it. The students' ability to work well in small-groups and figure out problems together provided support for her belief that students learned a lot from working with each other. Recognizing that she helped students learn to work together, and that she set up the problems for them to work on, she knew that she played an important role in facilitating peer-peer learning.

There was ample evidence of Molly's impact on student learning. Describing herself as "assessing all the time," she kept track of student understandings in a way that helped her be better able to guide students. This ongoing assessment of students' understanding also enabled her see her impact on them. Students' writing before and after math units clearly highlighted her impact on learning. Scores on chapter tests and the ASAT were very high, and the ASAT scores were, on average, as high or higher than students' previous year's scores. Molly even achieved the pattern of ASAT scores she wanted--high on computation, but higher on the applications and concepts. All of this evidence of learning provided additional support for Molly's strongly positive feelings of personal mathematics teaching efficacy.

Molly was able to teach in these ways because of the help of others, and because she helped herself. She was well prepared, and had a clear sense of how to guide a shared mathematical journey. The effectiveness of her teaching, and her efforts to educate parents about reformed practice had helped her parents understand and accept her way of thinking about mathematics. Molly's practice was also made possible by the vast array of commercial materials she had gradually amassed over the years, in part with money from parent fund-raisers. She had more than enough materials to teach in a reform-oriented way, and this wealth of resources allowed her to help others to teach math in more reformed ways. Substantial daily efforts by Molly allowed her to learn how to make use of such materials.

Although I don't think she had clear evidence of this, Molly truly believed the reform-oriented approach worked for all students, even "retarded" ones. In her classroom, she gave extra help to those students who were struggling with particular concepts or procedures.

Both motivation and learning. Molly prized both student motivation and learning as outcomes of her teaching, and while there was some tension for her between these outcomes, she also saw them as strongly interdependent. That is while motivation was necessary for learning, a type of puzzle-like learning was necessary for motivation. Consistent with the position that learning itself is intrinsically motivating (White, 1959), she believed that a certain kind of learning was motivating to the learner. The type of teaching that accompanied that form of learning was also motivating to her. In her view, failure to learn was a common cause of low motivation, and she justified learning one's math facts largely in terms of the motivational benefits of not getting bogged down on problems. Finally, the brain growth that she thought resulted from experience required experiences which were "associated with enthusiasm" by the learner.

Overall, Molly's experiences and beliefs regarding the benefits of reform-oriented mathematics teaching were mutually reinforcing. Important catalysts in the story included her efforts, efforts of students and parents, the teaching tools available to her, and the on-going assessment that allowed her to track progress. Imagining her teaching mathematics without the tools of the reforms was to imagine her feeling handcuffed as a teacher, and less effective, as when she noted her that she wouldn't know what to do without the overhead. It is implausible to think that she could have taught this way without her strong beliefs in the effectiveness of this approach (positive outcome expectancies), her confidence in her ability to teach this way (positive self-efficacy beliefs), and the ongoing effort she put into it.

Molly's efficacy beliefs. Molly indicated a positive belief in the ability of teachers in general to impact students, while noting that the home environment was important. Early in the study, she noted her belief that if teachers at Timberside used more reformed practices, students' problem solving would improve. This belief later found support in the school's higher second-year scores on the CLAS test, which she attributed to increased use of reformed practices by Timberside's teachers. She cited Peggy's and Beth's experience with the math lab activities (borrowed from Molly) as proof that teachers could impact both student problem-solving and liking of mathematics. Molly's influence on other teachers is the kind of organizational efficacy that Fuller et al. (1982) suggest is important, and would also satisfy some of the concerns or interests of a teacher well-advanced in the adoption of innovative practices (Loucks-Horsley & Stiegelbauer, 1991).

Molly not only indicated strongly positive personal mathematics teaching efficacy beliefs, but she also referred directly to her own experiences in explaining her answer, saying "I think I can." She noted specific outcomes she could influence, speaking first of her impact on students' liking of math, but talking a great deal more about her impact on their learning. Even Molly's disclaimers in this area suggested anticipated positive self-efficacy, as when she described that her use of rubrics for scoring problem-solving was evolving--"I'm not satisfied with that yet."

New grounds for feeling effective. Smith (1996) pointed to the need to identify new grounds for feeling efficacious when using reformed mathematics teaching practices. In Molly's case, I identified eight such new supports for feelings of efficacy. Briefly, Molly's students came to have improved attitudes and motivation towards mathematics, their problem-solving ability improved, as did their knowledge of mathematical terminology. They learned to use mathematics creatively, and showed progress in understanding--as represented in their writing about mathematics. They were increasingly self-regulated in their learning, and demonstrated a growing capacity to communicate about mathematics in small groups and in front of the whole class. Finally, there was the sense of accomplishment that seemed to accompany Molly's own construction of this mathematics practice.

Although self-efficacy in the sense of one's capacity to teach in certain ways was more the focus of Smith's (1996) list of possible new moorings for efficacy beliefs, the first seven of Molly's new supports for feeling efficacious are more related to personal mathematics teaching efficacy beliefs, in the sense of Molly having a valued impact on students. Only the last one clearly emphasizes gains in self-efficacy as defined in terms of executing particular actions. One possible reason for this pattern is that my research methods addressed teachers' perceptions of their impact on students more than they addressed teachers' ability to execute the teaching acts called for by the reforms. Nevertheless, self-efficacy in the narrower sense (one's ability to teach this way) was an obstacle in both Peggy's and Phoebe's cases. A second possibility is that, because Molly was further along in the adoption of the reforms, she was simply was more focused on student outcomes than on her own ability to teach this way. That would be consistent with research on the progression of teachers' concerns during the process of adopting innovations (e.g., Hall & Loucks, 1978). A third possibility is that, consistent with research on differences in goal orientations (Ames & Ames, 1984a), Molly was simply more focused on the task, and less focused on herself, and her own performance. Molly's comment "I don't think about me very much," is certainly consistent with the second and third interpretations above.

However, there was something more here. First, the nature of Molly's efficacy beliefs was such that they were not so much about control and her controlling others as they were about something else. This isn't to say she didn't believe that she could play a causal role, indeed an outcome expectancy is at the core of the case, that "dittos don't build dendrites." Since she could provide something other than dittos, this suggests she can play a crucial causal role. However, her belief about her own efficacy was not simply a belief about her, but rather, about her capacity, with the help of others, to bring about certain effects. From a Vygotskian perspective (1978), it was as if she was clearly acknowledging that her teaching practice always existed in her own zone of proximal development. That is, it was always something she was only capable of doing because of the supports of parents and students, and because of the cultural tools made available to her. Thus, while Molly maintained a strong sense of agency, the efficacy at work in her practice was not entirely hers.

Peggy Turner

The motivation story. Peggy wanted students to have fun with math and develop an interest in it. However, her experiences in mathematics had been negative, and she seemed to believe that not liking it was almost natural. She still didn't seem to like it well nor teach it with clear enthusiasm, and she thought she may have communicated her dislike of mathematics to students. Thus, while she believed she could have a lot of impact of attitudes and develop a love of math, she had simply let go of that goal one year. She thought that, if anything, she had turned off some students to mathematics. This belief seemed consistent with my observations that her students' enthusiasm for mathematics was modest or mixed.

Having been turned off to mathematics partly by her own failure experiences, Peggy believed that failure could dampen motivation and that success would boost subsequent motivation. Thus, she tried to avoid creating failure experiences for children, especially public failures, but students still struggled a great deal, and failed, in the problem-solving activities. This may have dampened student enthusiasm and engagement. Choosing problems with multiple right answers, and treating different answers as "interesting" fit with these beliefs, and steered her somewhat towards the reforms. Both

Peggy and her students seemed more engaged and more successful with problems for which there was multiple right answers. Just as this gave students success, Peggy had success making them successful, and found support for her belief that success elicits engagement. In discussions, she treated all sorts of incorrect answers as "interesting," so as to avoid feelings of failure. However, I thought she communicated clearly that some answers were more interesting and more correct than others. This was just one of the ways in which I thought she was not able to enact a practice consistent with her beliefs. Success was not sure nor failure always avoided in discovery activities either. Letting students work on problems for long stretches of time, and giving little or no guidance, such as teaching specific problem-solving strategies, students' success and engagement was often modest or mixed. A missing ingredient for bringing about more students success was knowledge. Peggy admitted her lack of expertise in facilitating discovery, and said she wasn't sure where to take discussions of mathematics once she got them started.

Although it was not entirely clear how this was reflected in her practice, Peggy expected more able or gifted students to be more motivated, because they had experienced more success.

A significant theme in Peggy's story was her use of rewards and punishments, despite her belief that she could get away from using them, and her ongoing desire to do so. A fair bit of her use of rewards and punishments was simply to maintain order during lessons, rather than to actually motivate learning. Lack of knowledge also seemed to be an obstacle to establishing a more positive pattern with regards to this issue. She lacked substantial knowledge of ways of motivating children without using rewards and punishments.

Peggy's experiences with both traditional and reformed practices provided no reason for great optimism regarding student motivation to learn mathematics. Some students liked to compute. However, with traditional practices, she thought the motivation evident while students did EXCEL worksheets was largely about racing to finish the worksheet first. Some students also liked to play with manipulatives and talk. However, with reformed practices, the greater motivation to play with materials or talk with friends fueled the behavioral problems that were an ongoing struggle for her. It wasn't helpful to her, even if it reflected her own experience--that she believed that learning involving manipulatives was naturally chaotic.

Peggy's outcome expectancies or beliefs suggested no motivational advantage of one approach to teaching mathematics over the other. I also observed no clear advantage of one approach over another for generating enthusiasm for mathematics. In one year, the students' vote indicated an even split in preference for one approach or the other, with a quarter of the class not liking either one.

Peggy's portrayal of motivation suggested occasional rather than ongoing motivation, and certainly didn't suggest a positive motivational cycle of Peggy and her students getting energy from each other. Occasionally, she implied that intrinsic motivation was boosted by success or dampened by failure, or that one was motivated by others to work for a reward, or avoid a punishment, but she didn't portray a complete or consistent picture of motivation.

Perhaps this pattern fit the motivation Peggy had experienced. Her students were occasionally buoyed by success or a reward, but sometimes seemed unmotivated. Most didn't seem strongly self-regulated in their learning, which was evident the few times she stepped out of the room. Peggy had tried some of the new teaching strategies because she had observed them succeed in workshops or because Molly had shared them with her. However, her own motivation for teaching math in particular ways seemed to be substantially shaped by external forces. First, she didn't experience teaching mathematics as intrinsically rewarding, and it often wound up "on the bottom of the stack." Second, as a self-described "people pleaser," she moved towards more traditional practices when pressured by parents, though she thought it was wrong. She even described society's need for students to understand mathematics as something that people at the state level knew "for a fact," rather than as something she knew for a fact. Overall, she didn't seem strongly self-regulated. She also often seemed generally unmotivated, which one year was in part in reaction to her negative feelings about parents and their teacher preferences. She hadn't invested the substantial energy needed to move steadily toward reformed teaching. Motivation to do mathematics was sometimes there and sometimes not, for both Peggy and her students, and the experience provided no obvious reason to move closer to reformed teaching.

The learning story. Peggy valued both traditional computation skills and the more reform-oriented goals. She believed students needed to understand the thinking behind mathematics and be able to solve problems, in order to be prepared for the twenty-first century. She alternated between reformed and traditional practices, and expressed the belief that you could mesh the two forms together, although she seemed to sense some contradiction in this.

Students struggled a fair bit in her class to make use of manipulatives and drawings to solve problems. Also, Peggy didn't emphasize clearly in her practice the connections between manipulatives and what they were to be used for, or what they referred to. Perhaps consistent with this, Peggy conveyed some sense that students' learning-by-doing progressed from the concrete to the abstract, but she never mentioned a stage or process of connecting the one to the other.

She believed in discovery, and that students would simply learn some things (including computation) when they were ready. However, this process was often unfocused in just the way she believed it had to be. Since she both wasn't quite sure how to facilitate such learning, such learning was a very slow and uncertain process, both in her beliefs, and in action. She portrayed learning as including processes of both pure discovery and of students learning from each other. She thought students sometimes learned better from each other than from teachers. By not teaching students problem-solving strategies nor giving more clear guidance to students, she didn't experience the way in which she could have more of an impact on students. This pattern was consistent with her passive portrayal of the teachers' role.

Overall, the clearest evidence of learning came more from traditional computation homework. Computation was the only aspect of her practice that she clearly linked to unambiguous success with regards to both learning and liking of mathematics. While she exhibited some belief that reformed practices had benefits for learning, she never offered concrete evidence for this, as she did for the benefits of traditional computation work.

Consistent with how Peggy had gained some mathematical skill as a student, but hadn't achieved any real understanding until adulthood, she once expressed the belief that students might not get understanding until adulthood. Despite some feelings of success in one year regarding students' computational skill, she generally didn't feel confident about what students had learned. Lacking any clear tool for ongoing assessment, and with the learning from discovery sometimes not emerging until weeks or years later, she was stuck waiting for chapter tests to get some indication of what students were getting from her teaching.

Not clearly confident in her ability in mathematics or mathematics teaching, the one clear example of parental influence was of parents pushing Peggy towards more traditional practices. She didn't seem to be pulling them any closer to accepting reformed teaching.

Finally, Peggy also thought different students learned differently, with lower-ability students needing a more traditional, directive approach. This may have provided her with a rationale for her teaching not being as reformed as Molly's.

Both motivation and learning. Unlike Molly, although Peggy noted the role of success and failure in motivation, it was not clear either in her practice or her reflection on it that she was consciously trying to balance the two as outcomes. Peggy also only noted weak linkages between motivation and learning. One linkage was the connection between success or failure and subsequent motivation.

However, as an observer, I thought motivation and learning were well connected in the story of her teaching. That is, not understanding or liking mathematics well, it was a low priority for her, which created a problem for her moving closer to the reforms, since that would have required a lot of learning, and coming up with "tons" of new "stuff." With this attitude towards the subject, and this view of change requiring a massive overhaul of one's practice over the summer, she had clear disincentives for making more substantial changes in her teaching practice.

Peggy's efficacy beliefs. She indicated a positive belief in the ability of teachers in general to impact students, noting that the home environment makes a lot of difference, but that you still can reach students. She believed it was very hard for teachers to impact students' attitudes about math, because many students decided early on that they didn't like it. She also made mathematics itself sound difficult to like.

Peggy indicated very high efficacy in this area, answering 1 to indicate she strongly agreed, at least in response to the Rand item, that she could get through to even the most difficult or unmotivated students in mathematics. However, her explanation for this seemed hypothetical in nature, something she said she had recently become convinced could be done, and could happen if she forgot about orderliness and whether students stayed in their seats or not.

It is perfectly understandable that Peggy's positive efficacy beliefs had to be explained with respect to a hypothetical future, since Peggy hadn't reached the point in her practice where her teaching provided clear support for these beliefs.

New grounds for feeling effective? Taken together, Peggy's practices provided only modest support for positive beliefs regarding the efficacy of the reforms, and both Peggy's outcome expectancies and self-efficacy beliefs provided little support for a strong move towards a more reform-oriented teaching practice. Despite fairly positive espoused beliefs regarding the overall efficacy of reformed practices, her vision of the reforms was that some reformed practices involved some chaos and reformed teaching put her in a fairly passive role as the teacher. Not having been well-armed with a vision of what such practice might look like, and the knowledge and skills to make it work, reformed teaching in fact worked less well for her in some ways than did traditional practices. It is not surprising that she sometimes did a traditional lesson just to feel like she had covered something,

For Peggy, the evidence that there were motivational or learning benefits to reformed teaching ranged from mixed to uncertain to negative, and such advantages came at the clear cost of reduced coverage of content. Not only did trying reformed teaching threaten feelings of efficacy, it sometimes involved handing control of efficacy to students during activities like discovery and peer-peer learning. Partly because of the way she conducted such activities, and partly because of how she interpreted her role, it seemed like she was giving away the capacity to be efficacious when using such practices.

However, Peggy's story could have turned out differently. With a little more effort and reflection, with gradual learning, and by making better use of the resource she had next door in Molly, things could have been different. Molly understood precisely how teachers sometimes struggled using a reformed approach, and had learned how to avoid some of the potential pitfalls. What if Molly had taught Peggy more about managing activities with manipulatives, about teaching problem-solving strategies, and about providing guidance for discovery learning? Unfortunately, since Peggy didn't want to get more than she gave in a relationship, she largely maintained her independence, but never got the help she needed. Peggy also seemed more oriented towards how her performance appeared to others, rather than being focused on doing the task at hand. This seemed to be an obstacle for her, given her anxiety about her performance. However, her focus on her performance may have been understandable given her lack of experience, her struggles with classroom management, and the fact that she was one of a handful of Black teachers in a predominantly White school.

Phoebe Notion

The motivation story. Phoebe wanted students to like mathematics and not be afraid of it. She had liked math as a student, which was procedural in her day, and thought students tended to like mathematics, unless it involved something they couldn't do. However, she said little else about her beliefs about what motivated students or made them like math, except that they liked playing games and using manipulatives. This was only a partial victory for the reforms, since she had found that her students preferred the traditional math to the newer approach. She thought this was because students considered traditional math to be "real math," a perception she probably did nothing to allay. Students did groan when she asked them to pull out the more reform-oriented Math in Stride workbook, and students were quite engaged during the traditional, very algorithm-oriented lesson on long division. Overall, student engagement and interest in mathematics was mixed, across students and across lessons.

Another issue for motivation was that Phoebe said some of her students "don't care," and came to school to socialize, not to learn. Many of her students did seem more focused on social rather than learning goals. When Phoebe wasn't focused on the students and ensuring that they complied, they often were fooling around, with only a few staying focused on learning. Phoebe concluded that students like hers were simply harder to motivate than those who valued learning.

Overall Phoebe expected compliance, and seemed to think punishment, or the threat of it, could motivate compliance, if not learning. Consistent with this, those who misbehaved were sometimes punished, and she used punishment as a threat. I never saw her use rewards, nor heard her talk about rewards as a way to motivate students. Her extrinsic motivation approach was directed more at conduct, and it was less clear what was supposed to motivate learning, except perhaps compliance.

Describing her own compliance as a product of the generation she grew up in, pivotal in Phoebe's reasons for trying some of the reform-oriented practices was that she was expected to do so. She complied as she hoped her students would. In this sense, her own motivation to teach in reformed ways seemed more to be more controlled by extrinsic forces, rather than being truly autonomous (Deci, 1995). Thus, she too could be motivated to comply, although her motivation seemed stronger both in areas she valued and in those she understood better. These included teaching mathematical procedures, social studies, and quilting and candlewicking. Phoebe described herself as a process-and-product person, and this seemed to be her general focus. Phoebe was at times intrinsically motivated to work on things that she thought were creative. However, she saw math as cut-and-dried, not creative, which was why she wasn't motivated to invest more into that part of her teaching.

Overall, there was no clear cycle of effects in Phoebe's portrayal of motivation. However, there was a parallel--she was expected to do certain things, and she expected certain things of her students.

The learning story. Phoebe had been good at doing the procedures of mathematics as a student, preferred learning how to do something rather than learning the reasons involved, and believed many of her students were not going to be great at mathematics. Thus, she focused more on developing rote skills than understanding. She had learned from experience that even teaching only rote skills could be difficult, especially with her students, many of whom came from troubled families.

Repetition was one key to Phoebe's practice, something that she believed was necessary to make math very mechanical, and she even suggested that understanding could become a rote process with enough repetition. Consistent with this, lessons moved quickly, with lots of repetition, and scarcely enough time to do the procedures she modeled before she moved on.

Modeling and corrective feedback were key elements of Phoebe's approach, as she believed students had to get it right and practice it correctly. With these elements in place, she did find that during lessons, many students were getting it right as they followed along with her. However, they usually did not understand it, nor do well on the subsequent tests. Sometimes she invested a great deal of energy, and students still learned little, and she still didn't understand why. Thus, while she tried to make mathematics "stick" through enough repetition of the correct form, she had little understanding of why this often didn't work, except to say that some students were tuned out. Phoebe didn't seem aware that particular features of her practices, such as her changes in inflection, allowed students to consistently get correct answers with need for little or no understanding of the task. She didn't do ongoing assessment of students, and thus often couldn't catch misunderstandings along the way. She relied on tests to see what students had learned and what they hadn't.

Phoebe had experiences to support her belief that manipulatives might help with understanding, but she didn't express clear confidence in this idea outside of geometry. Furthermore, she thought by the fifth grade, students should largely be operating at the symbolic level anyway. Most of her lessons focused on the symbolic level of understanding. She once cited a belief that students' learning progressed from the concrete to the abstract, but this seemed more like something she had heard somewhere rather than a deep part of her thinking. She never mentioned discovery. She didn't seem to have a clear idea of how students learned from manipulatives, but thought it required adult guidance. In my observations, she used manipulatives with largely the same procedural approach she used to teach computation, and she allowed little time for discovery. Even with self-correcting materials such as the worksheets, she still corrected students and told them what to do.

Phoebe said little to suggest that reformed practices like talking about math of using calculators were important for student learning. She did mention that calculators might change what students should learn.

Overall, Phoebe's practices and beliefs worked well as a coherent cycle when students in fact picked up rote skills from her modeling, correction, and repetition. However, with apparently only one clear model of learning in mind, she was left with persistent mysteries in her practice, such as whenever students didn't learn from repetition. This was a mystery to her in part because she seemed to view knowledge as transparent. She didn't have a clear model in mind either of discovery, or of how one would teach differently using manipulatives, nor how students would arrive at understanding through using manipulatives. She was left with quite some frustration. However, she was trying hard and doing the best she knew how. Without better information, materials and models of what reform-oriented should look like, it seemed unclear how either her practice or beliefs could change significantly.

There was no clear pressure from her often-uninvolved parents to change anything she was doing. Also, the school administration almost never came to supervise her, and as she saw it, she was trying to use the manipulatives which were what the reforms were about, and what she believed the administration expected of her.

Both motivation and learning. Phoebe said little about this, except to indicate that a lack of motivation created problems for learning, and that a lack of knowledge created problems for liking mathematics. More like Peggy than Molly, Phoebe didn't express any sense of strong overlap between motivation and learning. However, it seemed as if compliance was central to her model of how both motivation and learning worked. Motivation was based on doing what you were told to do. By repeating what you were told to do, and conforming to the correct model, learning would result as well.

Phoebe's efficacy beliefs. Phoebe felt she could have an impact on students, but felt she could make more of an impact on students if she didn't have as many negative home environments to deal with. In all fairness, I thought she had a very challenging population of students to work with.

Phoebe gave a response indicating moderately high personal mathematics teaching efficacy beliefs. However, part of her explanation for this centered on things that sounded out of her control--that most students enjoy math, unless they can't do it. Some of her explanations of how kids could come to "get it" also sounded beyond her reach--

depending on whether kids could "visualize it and comprehend it." On another occasion, she said that there was no student she couldn't reach in mathematics. On still other occasions, she said her actual impact was good in some years, not so good in others. If she thought she could reach every child in mathematics, but her actual impact was good some years, not so good others, was she too answering the Rand efficacy question partly based upon a hypothetical "I could" frame of reference?

Phoebe exhibited clear and strongly positive self-efficacy beliefs regarding her ability to teach in a way that focused on procedures, and used traditional methods. However, she had much more negative self-efficacy beliefs regarding her impact when using reformed practices. As she tried some new approaches, such as the tangrams, she indicated uncertainty about how to carry out many of the new ways of teaching.

New grounds for feeling effective? Overall, Phoebe's combination of beliefs, knowledge and practices provided very little support for truly reformed mathematics teaching. Sometimes the reforms were stopped by a combination of beliefs, knowledge, and experiences using reformed practices. While some of the reform-oriented practices were fun, they made classroom management harder, and she wasn't sure how they worked, if they worked, or how to do them. For example, her negative outcome expectancies regarding the effects of calculator use combined with lack of experience using them, and lack of faith in her ability to use the program skillfully (low self-efficacy). In the end, getting the new practices into use sometimes resulted in little change in her skepticism about their effectiveness.

If anything, Phoebe had lower personal mathematics teaching efficacy when using reformed practices. She also saw the impact she knew how to have on students as not enough, and she wasn't at all sure how to bring about understanding. Also, she and students still enjoyed the old way better. Looking back in her career, she thought she had more impact on students when they weren't as troubled, when she was teaching in traditional ways, and when she was using a mastery learning program. Not well armed with information, she did what she knew how to do. To try and reach this new goal of understanding, she walked students through problems, and "did everything but tell them the answer." The reforms had indeed de-valued her traditional grounds for feeling efficacious, but had brought her few new "supports" for feeling effective.

Phoebe's story might have turned out differently. She might have gotten more help from Jane, or other teachers. She might have found someone to team with, which she considered mandatory for effectiveness with reform-oriented practices. What would her efficacy beliefs story have been if her interpretation of the reforms was more about problem solving, and somewhat less about manipulatives? I think the pragmatic-sounding "problem-solving" would have appealed to her more than the more nebulous "understanding," and she might have found it less complicated to attempt in terms of logistics. I also saw no evidence that she ever really wrestled with the idea of discovery learning. This would have been interesting with respect to Phoebe's feelings of efficacy, since her version of causing teacher effects was to reinforce correct responses and extinguish incorrect ones.

Summary. In the final analysis, each teacher moved towards reform-oriented mathematics teaching during this study, and enacted some aspects of reformed teaching, but they varied greatly on this dimension. Phoebe didn't travel very far towards reformed teaching, Peggy moved away from reformed teaching during the third year of the study, and Molly didn't make it all the way there. However, the reforms influenced the practice of each teacher. Deeper conceptual understanding of mathematics could have helped each teacher do more to develop their students' conceptual understanding of mathematics. This is worthy of attention, and as in these cases, progress can be made in all teachers' subject matter knowledge and pedagogical subject matter knowledge.

I have summarized the cases of the three teachers, and examined the interactions between their beliefs and new practices. The way beliefs and practices interacted either enabled or stalled the reforms in each case. Fortunately, significant new supports for feeling efficacious when attempting reformed teaching were identified. These included supports for both personal mathematics teaching efficacy beliefs (e.g., "I can help students learn problem-solving skills"), and for self-efficacy beliefs as they are more narrowly defined (e.g., "I know how to teach using manipulatives"). Unfortunately, only Molly, a teacher of gifted students, really experienced these new supports for her feelings of effectiveness. Because of the reforms, Peggy and Phoebe may have lost as much or more than they gained in terms of feelings of efficacy, but their cases provide much fuel for thought.

I discuss next four larger issues that cut across these three cases. Based on the last three themes, I then propose a new model of teachers' efficacy beliefs.

Main Themes Across the Cases

What is the Motivation for Reform-Oriented Mathematics?

There was a certain parallel between each teacher's own motivation and the motivational patterns that seemed salient in her classroom. In Phoebe's class, compliance and punishment were salient, in Peggy's class the focus was on rewards and punishment, and the activity in Molly's class was centered on intrinsic motivation and self-regulation. These different ways of motivating are different ways of making change happen, or having an effect on others. Here, I examine these cases more closely, and relate them to the visions of motivation and of affecting others that are found in the reforms.

Phoebe's class. Coming from an age of greater unquestioning obedience to authority, Phoebe expected compliance. She didn't make unreasonable demands and wasn't mean-spirited, but did expect students to do as told. Providing for repetition of correct responses and giving sharp corrections to extinguish incorrect responses, she tried to cause effects directly, and her practice provided one illustration of the implementation of Thorndike's "law of effect" (Hunt, 1993). Phoebe more or less got the behavioral compliance she wanted from the class much of the time. However, despite doing mathematics as they were told, learning and understanding were very elusive for many of her students much of the time. Others continue to argue for the value of Thorndike's law of effect, noting that human behaviors is still "inescapably a function of its consequences" (Morgan, 1997, p. 154). Whether or not we believe that, Phoebe did control and shape many behaviors, but mysteriously to her, didn't get the learning she wanted. A central message of the mathematics reforms is that educators need an approach that does far more than shape behaviors. Mathematical power is more than a stock set of mathematical behaviors performed on cue. The kind of learning associated with impacting others through the use of strong controls may not be the most promising model for reformers.

Peggy's class. Peggy attempted to "control through seduction" (Kohn, 1993) part of the time, using rewards to motivate behaviors, and at other times, seemed to rely largely on the students' own motivation to persist at and learn from extended activities, whether traditional or reformed. Lacking a clear model of how such activities might elicit children's intrinsic interest, it thus seemed like she was part of the time controlling the children directly, and the rest of the time, largely relinquishing control to them. Peggy longed for an alternative to the extrinsic control model that she often used.

Molly's class. The most successful case in this study was characterized by a strong sense of intrinsically-motivated mathematics activity by students. Only Molly clearly emphasized in explaining her view of student motivation several elements (i.e., variety, success, and challenge) which are clearly connected to the literature on intrinsic motivation. Moreover, as discussed earlier, motivation was strongly interrelated to learning for Molly, and she didn't try to separate them, or to achieve one without the other. In a sense, Molly's approach to bringing about effects in students relied somewhat less on direct controls. She affected students more indirectly through their involvement in activities, through their enjoyment, interest, and learning.

Especially considering that Molly's implementation of the reforms was in some ways conservative, this finding also raises deeper questions about the threats posed to feelings of efficacy by attempting reform-oriented teaching. It is not simply a matter of mastering new methods to cause new effects. The very nature of one's causal agency is different as well, not simply weaker--as it was with Peggy's laissez-faire approach during discovery--but qualitatively different.

These parallel patterns of motivation found in teachers and students are important because of the emphasis in the California mathematics reforms on self-regulated learning and intrinsic motivation.

The 1992 California Mathematics Framework stressed self-regulation as a necessary feature of higher-order thinking, which comes under the first dimension of mathematical power. The reform authors didn't distinguish between introjected and integrated self-regulation, but I assume they would favor the latter form if they were aware of the difference. That is, integrated self-regulation tends to be the form of internalization more common when reasoning is used (as was emphasized in the reforms). Introjected self-regulation is more common when internalization is associated with others asserting their power (Deci, 1995), or demanding compliance (as Phoebe did). Thus, introjected self-regulation seems more consistent with a more traditional approach.

Intrinsic rather than extrinsic motivation seemed to play a key role in the reform vision reflected in the California framework, although it was not directly discussed. For example, intrinsic motivation, perhaps of the curiosity motivation form (Berlyne, 1966), or of the competence motivation form (Piaget, 1952; White, 1959), seemed implicit in the Framework's claim that "children do not have to be motivated to learn; they do it naturally" (p. 32). The very first item listed in the Framework for the role of the teacher, under "supporting and facilitating learning," is this: "How can I structure the classroom environment and my interactions with students so that they want to confront and make sense of mathematics" (p. 50)? The form of this question suggests that the author is favoring an intrinsic motivation approach over an extrinsic motivation approach. A question that better reflects an extrinsic motivation view and approach would be "How do I motivate the children to learn math?" As Deci (1995) explains, from the perspective that people have to be extrinsically motivated, motivation is something you do to people. From the perspective of intrinsic motivation, motivation is something people do, and the issue is how to create conditions in which they will better motivate themselves.

Thus, self-regulation and intrinsic motivation appear as important issues across the three teachers' cases, in those teachers' classrooms, and in the reforms themselves. In the most successful case of this study, the teacher tried to elicit intrinsic motivation and develop self-regulation in her students, just as her own motivation seemed to reflect both strong intrinsic motivation and integrated self-regulation. The model of causality in the more successful case was a more indirect one, of influence more than of control.

Peggy's struggle to move away from relying on extrinsic "motivators" was characterized precisely by a lack of understanding of intrinsic motivation, and by her ongoing attempts to control students. She hadn't learned about intrinsic motivation or how to maximize it. It was unfortunate that neither the nature of intrinsic motivation nor how to elicit it was explained in the California mathematics framework, nor made a more central part of the reform effort.

Other research suggests that strong reliance on extrinsic motivators may yield results inconsistent with the reform purposes. Rewards tend to make power more salient and reason less salient as a basis for action, while the reforms emphasized reason. Also, using rewards often leads students to focus on doing only what they have to do to get the reward. Such an outcome would seem to work against the creativity, divergent thinking, and higher-order thinking emphasized in the reforms (see Kohn, 1993).

In sum, intrinsic motivation and integrated self-regulation were key themes in the reforms, and for Molly and her students. Extrinsic motivation and introjected self-regulation were themes in the cases of less successful reform-oriented teaching. Other research suggests that the use of strong extrinsic controls may be at odds with reform purposes. Also, the most successful case was characterized more by a model of impacting students indirectly, and less by controlling students directly. These points raise questions about the recent suggestions to better motivate teachers to engage in reformed teaching by using stronger extrinsic controls (see Fuhrman & O'Day, 1996).

Teachers' Efficacy Beliefs and Their Interpretations of Their Roles

There is a seemingly paradoxical finding in the contrast between Molly, who had moved much further in the direction of the reforms, and Peggy, who had tried to do so, but struggled. The paradox is that Molly did more leading than Peggy did, and students really did more discovery, and more successful and rewarding discovery. Molly both taught more, and the students took a more active part in their own learning.

This paradox is created by Molly's and Peggy's different interpretations of the role of the teacher in reformed teaching. Peggy's view of and approach to the reforms resulted in a loss of perceived causal agency to students. She lacked a perceived role in facilitating discovery and peer-peer learning, and seemed unable to take some credit for learning attained through these processes. This meant that adopting the reformed approach entailed giving away some of her felt ability to have an impact on students. Watching her teach this way, I too sometimes wasn't sure what she had taught students, or helped them learn during a lesson. Smith (1996) points to this loss of perceived causal agency as a threat to teachers' efficacy beliefs, which in turn poses as threat to the success of the reforms.

Certainly, lack of knowledge regarding reformed teaching was an obstacle to reform in Peggy's case. We might even conclude that Peggy's particular problem resulted from misconceptions she had about the reforms, including outcome expectancies pointing to a chaotic process of learning from manipulatives. However, Peggy had been to several workshops on reformed mathematics teaching, and had learned about the reforms from Molly's sharing of ideas and materials. She sounded closer to the reforms, and more interested in the reforms than most of the teachers I heard about or encountered during this study. If Peggy had fairly simple misconceptions about the reforms, even after this massive reform effort, many other teachers probably had such misconceptions as well.

However, we might conclude that Peggy had encountered accurate information about the reforms, and that her interpretation of the reforms was in fact accurate based on the information she received. Trying to sort this out, I turned to the 1992 California Mathematics Framework. On the first page of the section in the framework on the "role of the teacher" is the following quote:

> No longer is it your responsibility to watch for every mistake and correct it on the spot. Instead, authority is delegated to the students and to groups of students. They are in charge of insuring that the job gets done, and that classmates get the help they need. They are empowered to make mistakes, to find out what went wrong, and what might be done about it. (p. 49)

A reasonable person reading this might assume that control and causal agency has been given to the students, since "authority is delegated to" them, and "they are in charge of insuring that the job gets done." While some other parts of the section on the teacher's role outline ways teachers can be more active, there still is a heavy emphasis in this section on the activity and self-directed nature of the learner's learning. Ball and Chazan (1994) pointed out that a common interpretation of the reforms is that there is a prohibition against telling students things. Along these lines, one of the main "guiding principles" for teaching for understanding listed in this section suggests that the teacher's job is to set up situations, ask questions, and listen to children, "rather than trying to teach a concept through explanation." Now, I have no knowledge that Peggy read these particular passages, let alone that they were pivotal in her understanding of the reforms. Nevertheless, the existence of such main points in the reforms makes it quite understandable how Peggy, and others, could have constructed the interpretation that there is a fairly passive role for teachers in reformed teaching. Peggy did have some understanding that teacher guidance could help such learning along, but if giving explanations wasn't an allowed part of that, and is she had already largely given authority over to the students, as she was supposed to, what was she to do? Why wouldn't she feel ineffectual?

To be fair, the reform documents contain much more than I have reported here, and much of it suggests other things teachers should do, and ways in which their role is more active, and transformative. However, the section on the role of the teacher is only five pages out of this more than 200-page document. This section on the teacher's role not only suggests the transfer of authority noted earlier, but also the role of the teacher in setting up situations and as a guide. Peggy might have needed a clearer sense that she still could influence students in important ways in the new approach, but she also needed greater guidance from reformers on how she was supposed to provide guidance in reformed activities. That is, she needed changed "outcome expectancies" regarding the nature of this learning, and new skills, to create grounds for new feelings of self-efficacy.

Molly's agency was still intact. Loss of agency clearly wasn't a problem for Molly, who cheerfully acknowledged that students knew things she didn't and they learned a lot from each other, but who also had a clearer sense of how she helped bring about students' learning and liking of mathematics. Molly didn't feel like she had to be the source of all knowledge, but she was the source of a lot of it. She knew students needed to struggle and puzzle on their own and together to learn problem-solving. However, she also knew she had to make it a focus and help them learn problem-solving strategies if they were to become skillful. She may in fact have gotten energy back from students, but she was the one who got that positive motivational cycle rolling.

Molly avoided the "early childhood error" (Bredekamp & Rosegrant, 1992) of not giving enough structure, a common issue in Peggy's case, and the "elementary error" of too tightly structuring students' activity, an issue in Phoebe's case. In a sense, Molly avoided loss of agency by finding some middle ground, or perhaps different ground. While Phoebe had continued to teach in a quite traditional manner, even with manipulatives, Peggy's teaching practice involved alternation between major segments of traditional practice and major segments of attempting more reform-oriented practice. The meshing of the two that she spoke of and hoped for was never quite apparent, perhaps even to her. In

Molly's case, the traditional and reform-oriented elements of teaching and learning were much more interwoven, with ongoing alternation between discovery, modeling, problem solving, and telling. Sometimes the period for discovery was as short as ten or fifteen seconds, such as when she allowed students, sometimes with her guidance, simply to figure out an answer. Sometimes periods of modeling or telling were just as brief.

Dichotomous thinking in reforms. In a sense, Peggy's view was of a dichotomy, contrasting reformed teaching on one extreme with traditional teaching on the other. Such a dichotomous view is consistent with statements about the nature of reformed teaching, such as those cited earlier from the 1992 California math framework. Posing the traditional and reformed as if they were two ends of a continuum, Peggy sometimes taught at one end, and sometimes at the other. Researchers and reformers often define something new by posing it as a direct contrast with the familiar. They do this by using phrases like "but rather" as pivot points in sentences where the old is left behind and the new view or approach is introduced, often casting the new approach as if it were entirely new. This approach to defining the new may reinforce dichotomous thinking, and the view that the choice is between two opposing alternatives. However, Hegel didn't suggest that progress in thought comes from simply having a thesis and antithesis, or perhaps from alternating between the one and the other, like the endless swinging of a pendulum (see Frost, 1962). Such alternation seemed to be the case in Peggy's practice, and often seems to be the case as the pendulum of education swings from traditional, to reform attempts, and back again. Debate between two opposing views can be helpful, but Hegel suggests that the qualitative leap forward in thought comes from the synthesis resulting from a transformation in which elements of both the thesis and antithesis are combined.

With Peggy's view of the reformed approach as a monolithic alternative to traditional practice, it made sense that she never got over the hump to a practice that seemed in the majority reformed. It is interesting that some mathematics educators felt compelled to write a paper reminding teachers that it was still all right to "tell" students things (Ball & Chazan, 1994). This suggests that Peggy wasn't the only one who thought the reforms had entirely taken from her even such a basic tool of teaching. With a more incremental view of her own progress, and a view of the reforms as more a synthesis of traditional and very new elements of teaching, progress might have seemed much more possible.

While posing the new versus the old as a dichotomy gains attention and establishes a clearer contrast in the short run, such a formulation may make the new approach seem too extreme for some. Also, such a formulation may hold the seeds of future problems for the reforms, even for those who attempt reform-oriented teaching.

New explanations of the teacher's role? Perhaps the more helpful statements of the reforms are those that contain both the learner's and the teacher's agency in the same breath. An example of this comes from the section on the teacher's role in the 1992 California framework, in a description of the ideal classroom: "It also provides a variety of ways for pupils to direct their own learning under the mature, patient guidance of an experienced, curiosity-encouraging teacher" (p. 49). However, even with such statements, the reader still has to provide their own synthesis, since the student is first strongly characterized as directing their own learning, with the comment about the adult role then modifying the issue of agency somewhat. Somewhat different statements reflecting somewhat different visions may be needed, although it's not yet exactly clear what these should be.

A new position statement on "developmentally appropriate practices" from the National Association for the Education of Young Children (Bredekamp & Copple, 1997) takes on this issue more directly. Based on their experiences with misperceptions of developmentally appropriate practice as obstacles to change, they advocate getting beyond "either-or" thinking, and moving towards "both-and" thinking and dialogue. They give an example of what they advocate, "Children construct their own understanding of concepts and they benefit from instruction by more competent peers and adults" (p. 23). If anything, Molly's case provides support for adopting more of a "both-and" perspective and approach. Such a shift in perspective and language should lead us to more productive questions about how, when, and why to interweave the traditional and the reformed.

<u>Interdependent Efficacy and Related Efficacy Beliefs</u>

I now turn to the nature of perceived efficacy and efficacy beliefs regarding mathematics teaching in these cases, with a particular focus on Molly's feelings of efficacy.

Certainly, the basis for Molly's feelings of efficacy was distinct, given her strong valuing of both motivational and learning outcomes. However, perhaps as significant was the way in which both motivation and learning were strongly interdependent in her thinking and teaching, and how success in teaching required keeping an eye on both, and learning tasks where the two processes stayed intertwined. That is, Molly thought that it was a particular sort of task that both elicited engagement and allowed for meaningful, mind-stretching learning. This contrasts with an approach where motivation stands apart from learning, but drives it, as with Peggy's use of Goldfish crackers as motivators for learning from a story. In Molly's approach, motivation and learning feed each other, and to be effective required keeping them intertwined. In this study, problems in learning and motivation were found more often in the two cases in which motivation and learning were treated more as independent entities. The view of motivation and learning as more separate is more consistent with an extrinsic view of motivation, while the view that the two processes are intertwined is more consistent with an intrinsic view of motivation (e.g., Stipek, 1988). While a great deal of literature has documented the advantages of intrinsically-motivated learning (e.g., Kohn, 1993; Stipek, 1988), my point here centers more on Molly's view and approach. In my child development classes, I teach teachers <u>about</u> intrinsic motivation, and many, seemingly hearing about it for the first time, immediately ask how they can "intrinsically motivate" students. Their perspective still suggests motivation as something you do to others, which then drives learning, but which stands somewhat apart from learning. Molly's case suggests the benefits of not simply knowing facts about intrinsic motivation, but of viewing and treating motivation and learning as more interdependent, and as dependent upon certain sorts of tasks and interactions. Her perspective thus was much more consistent with research into achievement motivation in which motivation and learning are viewed as highly interrelated (e.g., Ames & Ames, 1984c).

Almost paradoxically, the teacher who personally felt most efficacious and was most aware of what effect she was having on students seemed least focused on her own self and her own self-efficacy. Molly felt very capable of carrying out the teaching act (positive self-efficacy), and believed many of the things that happened in her lessons would result in students liking and learning math (positive outcome expectancies). She also had faith in her capacity to impact students' liking and learning of mathematics (positive mathematics teaching efficacy). However, she seemed to think more in terms of what students were learning rather than how her teaching was going or even how was she impacting students. It was actually hard to get Molly to talk about herself. She didn't seem at all defensive, but didn't seem interested in talking about herself, and her answers to my questions about herself would consistently begin with a focus on herself, but then drift back to talking about students, what they did, and their thinking and learning. Molly seemed totally focused on the task at hand during teaching, which for her meant students' learning. As she said, "I don't think about me very much." Thus, she provided a clear contrast with Peggy, who seemed more focused on her own performance, and was concerned with how she was doing or how her performance appeared. Peggy spoke a great deal about her thoughts about herself, and much less than Molly about students and their learning. The salience of thoughts about self and performance in Peggy's case is consistent with the "performance orientation" in the literature on goal orientation, while Molly's lack of focus on self is characteristic of both a learning or task orientation (Ames

& Ames, 1984a), and of someone with highly positive self-efficacy beliefs (Bandura, 1981).

Something new. However, there was something else to this. Molly was not simply focused on a task rather than the self, she was focused on others, and their actions and thinking. This focus makes sense because Molly's actual efficacy and thus, her efficacy beliefs, were based on a system of dynamic, interdependent relationships. Molly saw learning and motivation as not only interdependent with each other, but as outcomes that both she and the students created together in the classroom. Molly helped parents understand the new approach to mathematics, and they supported her approach, and helped her have more time for such teaching, by teaching their children computation at home. Molly was also freed to have more time to plan for mathematics because the science lab teacher handled most of science instruction, but Molly had spearheaded the creation of the science lab. Molly also didn't consider herself very creative, and depended a wide variety of sources for her teaching materials and activity ideas. She couldn't have kept students' attention as she did without the overhead, nor engaged them in such "brain-stretching" activities without calculators or all the resources that others had created. As the year went on, students' growing capacities for both problem solving and self-regulation changed the degree to which she could have an impact on them. Students could attempt more and more challenging problems and function more independently. Together, she and students, with significant outside help, created "auspicious cycles" of growth for each other. Looking across the cases, only in Molly's case was it so clear how positive classroom effects were jointed constructed by the simultaneous efforts of her, her students, and others, and by the affordances of the cultural tools she had at her disposal.

Interestingly, Bandura (1981) suggests that needing others' help to execute tasks is often taken as a negative cue about one's abilities, which leads to lowered feelings of self-efficacy. I detected no decreased sense of efficacy in Molly's case due to relying so much on others and on cultural tools. Perhaps there was more than enough "efficacy" to go around. Also, Bandura acknowledges the role of interpretation in determining the effects of performance information on efficacy beliefs. Perhaps interpreting the need for help as a cue for decreased feelings of efficacy is only sensible when one's view of efficacy favors self-efficacy of a very independent sort. Thus, if one adopts the "triumphant individual" view of achievement and competence (Reich, 1987), achieving effects collaboratively may threaten one's feelings of efficacy.

In her hesitation and inability to get teaching ideas from an expert math teacher who wanted to share them, Peggy seemed more stuck in the independent, "I can do it myself" view. This clearly handicapped her. The seeming paradox may be that what we call "independence" isn't achieved nor maintained alone, but is done with others' help. What observers might point to as both Molly's and the students' apparent independence had its roots in a well-managed interdependence. Even in the budgie example, the ability of students to work independently was something they had been working towards, by working first together with each other. Thus, Molly announced that they would depart from their usual pattern of working together, and each students would do that problem on their own.

A similar pattern is found even in the first few years of life. Those infants with a more secure attachment with their parent, who received more consistent and sensitive caregiving, are those who are later judged to be both more independent, and more able to use the assistance of others skillfully (Berk, 1996). The characteristic form of interaction that is associated with developing such a secure attachment, with its associated benefits, is actually described as interactional synchrony (Isabella & Belsky, 1991), a harmonious back-and-forth interaction pattern requiring both mother and child to skillfully adapt to the actions of the other.

Where growth happens. Vygotsky (1978) suggests that the most meaningful individual growth only occurs from engaging in those tasks that lie in one's zone of proximal development--that require the assistance of others for successful execution.

Molly's case, the concept of the zone of proximal development, and the points about the origins of competent functioning suggest something. They suggest the need to extend our conception of what efficacy is, and of what efficacy perceptions may refer to. Especially for a range of tasks as complicated as those involved in teaching, we need to attend to feelings of efficacy based on accomplishments that are constructed together, by people in dynamic and interdependent relationships. It is not simply that the "culture of teaching" reinforces the valuing of competent performance achieved alone--our broader culture teaches this view about competence more generally. This view is also reflected in the emphasis in the efficacy beliefs literature on efficacy conceived of and achieved alone. This was not Molly's view, nor how she explained her effectiveness in teaching mathematics.

While it was not among my initial research purposes, another significant difference across the three cases was the motivation for teaching and learning in reform-oriented ways. Perhaps these cases can help shed light on a recent question in the educational policy literature: "What motivates teachers to put in the hard work required to substantially improve student learning? Can reformers and policy makers create incentives to motivate, support, and maintain a commitment to such change" (Fuhrman & O'Day, 1996, p. 1)?

The three cases at hand certainly provide different stories of motivation to engage in reformed mathematics instruction, along with significant variations in the implementation of reforms. Thus, I turn next to analyze the teacher cases as examples of different types of motivation, and relate the motivation patterns salient in each case to the depiction of motivation in the reforms themselves.

The teachers' own motivations. Phoebe had some faith that some of the reformed practices would work, but was attempting them in part out of a sense of duty, and to comply with what was expected of her. Peggy talked more than Phoebe about the reasons behind the reforms, but still seemed to be teaching in particular ways because it was what she should do--what she felt pressured to do. Peggy's teaching didn't seem to be coming from what she wanted to do based on a deeply-held set of values, but rather she seemed to be responding to what she should do. Thus, both Phoebe's and Peggy's motivation seemed more "controlled" rather than truly "autonomous." This distinction arises in literature on internalized motivation (e.g., Deci, 1995). To be "controlled" is to be motivated to respond to external pressures or by values that one has internalized but not fully digested, or not fully made one's own. Deci refers to such motivation as introjected self-regulation. This contrasts with motivation based on values that have been reflected on, and have become a part the true self, which he refers to as autonomous or integrated self-regulation. Deci notes that people with either introjected or integrated self-regulation may do the actions that people in authority desire, but that those whose self-regulation is based on introjected values may perform less consistently, and less well. Other problems, such as rebellion, are also more common with introjected self-regulation. Of the three teachers, only Molly's motivation to use reform-oriented practices, and her self-regulation, seemed truly autonomous. Finally, of the three teachers, only in Molly's case did the act of teaching mathematics seem to be strongly intrinsically motivated.

Helpful Information on Efficacy Beliefs from Qualitative Data

I end with a point about methods, that taking a "qualitative" case study approach to studying teachers' efficacy beliefs yielded extremely helpful and interesting information.

In some cases, the interview data extended the information available from the teachers' self-rating on five-point Likert scales. For example, the teachers seemed to have different things in mind when answering the question about personal mathematics teaching efficacy. Some answers seemed rooted in what really was the case at present for that teacher, and others were linked to what could be true for them in some hypothetical future. For example, Molly explained her highly positive self-rating of "1" on the personal mathematics teaching efficacy question in terms of what she in fact had accomplished. In contrast, Peggy explained the exact same self-rating in terms of what she thought she could do in the future--if she could only change her teaching in particular ways. Follow-up questions to Peggy revealed that she was quite unsure, and often felt badly, about her actual impact on students in mathematics.

Interview data allowed me to explore the reasons behind teachers' answers. Peggy and Phoebe were unsure about the effectiveness of reform-oriented practices, but part of their story was that they lacked, or didn't use, any method to assess student understanding in an ongoing way. Peggy didn't clearly feel more effective using reform-oriented practices. However, she also acknowledged not spending enough time on planning so that the reformed approach might work as well as it could. Peggy didn't simply expect using manipulatives to be harder to use; she described that way of learning as involving chaos. Gathering interview data also helped to identify areas where teachers felt they could do better, but didn't have the knowledge, or the materials, or the learning experiences that they needed.

Observation data allowed me to make better sense of each teacher's comments. Both Phoebe and Peggy felt that teaching by using manipulatives sometimes took too long. However, there was an enormous difference between the two teachers in how quickly they moved their classes through activities involving manipulatives. Molly and Peggy made almost identical comments about learning from discovery, but discovery was very different in the two rooms.

Artifacts, like worksheets and handouts for parents, helped me to make sense of observations and interviews, and provided suggestions for subsequent observations and interviews. Molly's "dittos do not make dendrites" quote came from a handout for parents. This led me to other questions to her about the different effects of traditional versus reformed teaching.

Overall, a case study approach allowed for a more complete and contextualized picture of each teacher and their teaching. This helped make information regarding teachers' efficacy beliefs much more meaningful, and intelligible.

My Model of Teachers' Efficacy Beliefs

Overview

Based on this study, I developed a model of teachers' efficacy beliefs, graphically represented in Figure 1. This model points to the crucial role of social influences, social interactions, and teachers' interpretations in the formation of teachers' efficacy beliefs, and in the impact these efficacy beliefs have on teaching. I explain the details of the model below, using examples from the three teacher cases in this study.

Socially-Created Student Outcomes

All three teachers explained their beliefs regarding their mathematics teaching efficacy by referring, to varying degrees, to actual student outcomes. All three teachers also acknowledged the role of students, parents, the school, or others in influencing these student outcomes. However, there was variation between the cases in the degree to which the teachers enlisted others' help, and in the ways in which others influenced student outcomes. For example, Phoebe made much less use of students or parents as a resource than did Molly. In Molly's teaching and in her interpretations, positive patterns of interactions with students, parents and others were pivotal in bringing about positive student outcomes. Regardless of the degree of success that teachers have in setting into motion positive cycles of interactions with others, this model is based on the premise that student outcomes are created jointly, through the efforts of students, teachers, parents and others. These outcomes are one of the factors affecting teachers' interpretations regarding their efficacy.

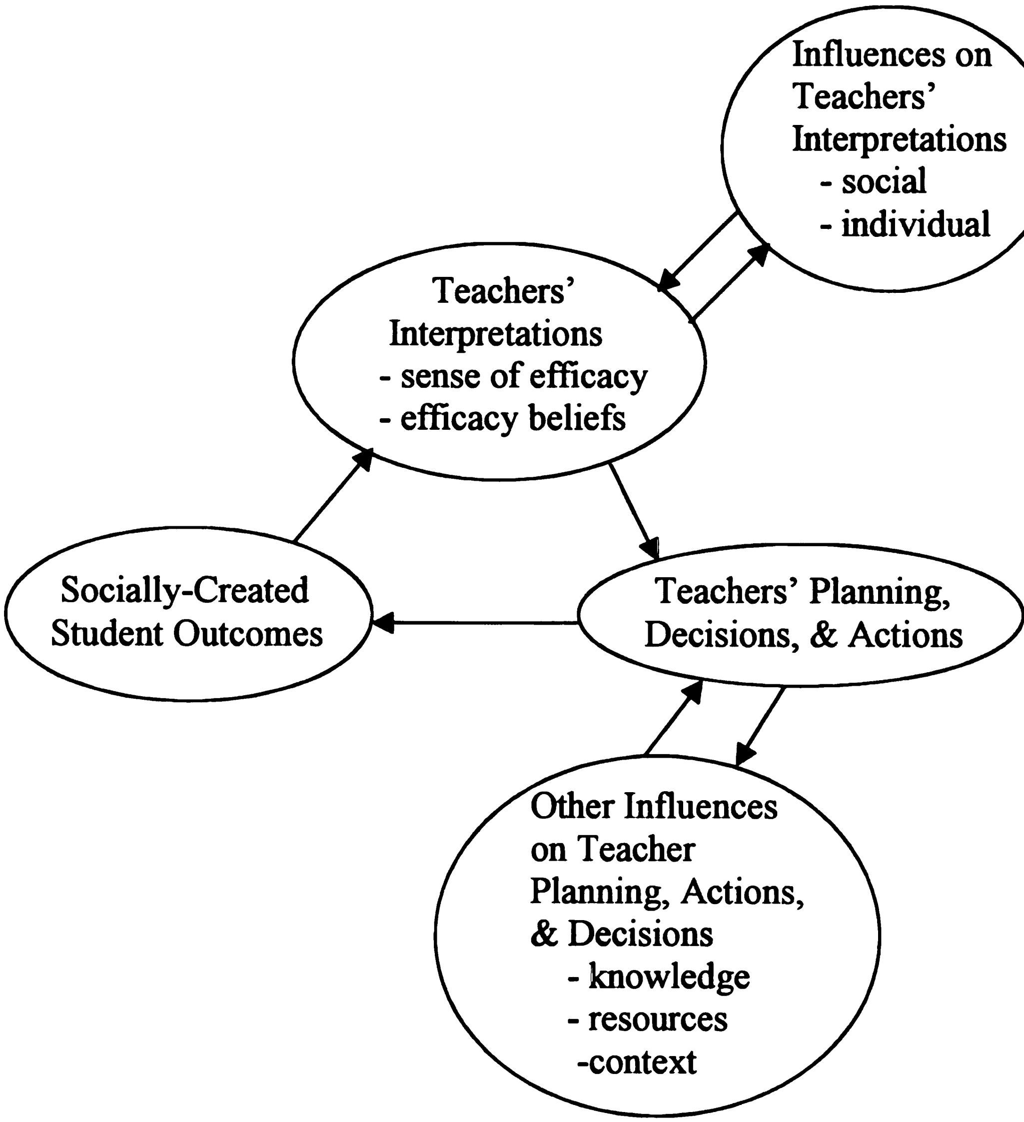

Figure 1 – A New Model of Teachers' Efficacy Beliefs

Other Influences on Teachers' Interpretations

Also influencing teachers' interpretations of their efficacy are a variety of individual and social factors.

Individual Factors

Teachers' knowledge, goals for teaching, and beliefs all influence their interpretations of their efficacy. For example, Molly seemed to have a better understanding of her students' ability and understanding of mathematics than did Phoebe or Peggy, and this allowed Molly to feel more certain regarding how effective she was. Molly's goals for teaching mathematics (e.g., problem-solving), based on her interpretation of the mathematics reforms, meant that she felt very effective teaching mathematics. If her goals had shifted more towards having students develop a principled understanding of mathematics (see Lampert, 1986), this shift in goals may have led to a somewhat less positive sense of her own teaching efficacy. If a teacher's understanding of mathematics is not very extensive or is very focused on procedural knowledge, their knowledge of mathematics influences their interpretation of their efficacy differently than it would if they had a deeper or different understanding of mathematics.

Social Factors

Teachers' education, the context in which they teach, and educational policies or reforms movements all may influence teachers' interpretations by shaping their knowledge, their goals, and their understanding of teaching and learning. If parents' goals for learning mathematics conflict with the teachers' goals, or those of the reforms, as was true in Peggy's case, social and individual factors may send mixed messages regarding a teacher's efficacy. Phoebe and Molly taught in very different ways, and had very different levels of parental involvement in their classrooms, but each felt that feedback from parents was supportive of their approach to teaching, and their effectiveness as a teacher. Given the context in which she taught, and the kind of students she had, Phoebe thought that teaching her students procedural skills signified a meaningful teaching accomplishment. She suggested that using the yardstick of teaching for understanding to assess teaching effectiveness was a little more realistic for teachers with more capable students, from less troubled and better-educated families.

Teachers' Interpretations of Their Efficacy

Influenced by student outcomes and the other individual and social factors noted above, teachers form interpretations regarding their efficacy. The effect that factors such as a teachers' goals or teaching context have on their efficacy interpretations depends a great deal on how they interpret these factors.

Sense of Efficacy

One type of teacher interpretation regards their past teaching effectiveness, which I refer to as their sense of efficacy. Constructing an interpretation of how successful one has been in teaching is a very complicated task. At times, Phoebe felt students had learned very little, but that she may have been as successful in teaching a difficult group of students as any teacher could be--"You can't get blood out of a turnip." A teacher in her situation could feel good or bad about her effectiveness, depending on how she interprets such an outcome. This points to the complicated relationships between teaching context and one's sense of efficacy, or efficacy beliefs. For example, if a teacher interprets her teaching efficacy by assessing her students' progress with respect to the average classroom, teaching gifted students is likely to enhance one's sense of efficacy while teaching low-ability students is likely to undermine it. However, a teacher may interpret her efficacy with respect to criterion-referenced standards, rather than norm-referenced ones. If a teacher does this, a teacher of very low-ability students who learn slowly may still find grounds for feeling very effective. This is an example of how the effects of context on a teachers' efficacy interpretations depend a great deal on how the teacher interprets both the context, and what outcomes mark effectiveness in that context. As a further example of the role of interpretation, even a teacher who views her mathematics teaching efficacy as below average may feel good about her teaching efficacy if she has reason to believe she is steadily becoming more effective.

It is also important to note that teachers have multiple goals for students, and feeling effective regarding some goals may come at the expense of feeling effective regarding other goals. For Peggy, even if students were really coming to understand mathematics from all of that noisy and chaotic activity with manipulatives, that approach to teaching and learning was costing her some of her sense of efficacy regarding control of the classroom. For Molly, being a little less effective with learning was acceptable if that allowed her to be more effective in sustaining students' positive dispositions towards mathematics.

In general, one's sense of efficacy regarding past teaching is one important influence on one's efficacy beliefs regarding future teaching.

Efficacy Beliefs

Other efficacy interpretations relate more directly to teachers' efficacy beliefs--their beliefs in their capacity to have an impact on student outcomes in the past, present, or future. A teacher may believe that she could have had an impact on students in the past (positive efficacy beliefs), but didn't have as much impact as she could have (negative sense of efficacy). This happened in Peggy's case. This situation is more likely to lead to feelings of guilt than is the kind of situation described above regarding Phoebe, where she felt she had little impact on students (negative sense of efficacy), but doubted anyone could have impacted those students much (negative efficacy beliefs). Having positive efficacy beliefs regarding future teaching requires that teachers believe that there are some actions that will lead to the desired outcomes, and that they, or they together with others, are capable of carrying out the actions that yield the desired results. Knowing about actions that may have desired outcomes depends on teachers' knowledge of subject matter and of teaching methods. In this way, and others, teacher knowledge influences teachers' efficacy beliefs.

Given the complex nature of reform-oriented teaching, a crucial aspect of teachers' efficacy interpretations is whether they view teaching efficacy as something that is achieved alone or through collaborative effort. In one interpretation of achieving teaching effectiveness through collaboration, parents, students, the teacher and others influence each other reciprocally, and create motivation and learning through their joint efforts. I suggest that having this interpretation makes reformed teaching much more likely to be attempted, and more possible to achieve. Reciprocally-beneficial interactions between teachers and students, teachers and teachers, or teachers and parents, allow for a very helpful synergy to develop in the educational process. However, if one interprets teaching efficacy as something that should be achieved largely on one's own, even success achieved collaboratively can still threaten one's sense of efficacy regarding past teaching. Also, if one's image of efficacy is that of solitary achievement, the synergy described above is less likely to develop, and being effective with the ambitious practices called for by reformed mathematics teaching may be much harder to imagine. Thus, efficacy beliefs regarding the future are much more likely to be negative. For example, when Peggy spoke the most negatively regarding her capacity to teach mathematics effectively in reform-oriented ways was when she was imagining this as a solitary task, as when she described how really trying reformed teaching would require her to come up with "a ton of stuff" on her own. However, when she sounded the most confident regarding her ability to teach in reformed ways was when she was imagining herself team teaching with others. For her part, Phoebe believed that success with truly reformed mathematics teaching was impossible without teaming, especially given the multiple reforms that teachers in California were trying to manage.

Reinterpretation

An important element in the formation of teachers' efficacy beliefs, particularly in the context of educational reforms, is the process of reinterpretation. To begin with, one sort of re-interpretation is the way the reforms ask teachers to re-frame their past impact on students, even if those teachers felt very successful with traditional teaching. Also, teachers who take an active role in their own learning about reformed teaching will initiate reinterpretation of their teaching effectiveness, through ongoing reflection on student outcomes. Since learning involves gradual construction and re-construction, the ways in which teachers attempting reformed teaching assess their effectiveness must involve review, re-interpretation, and on-going change in how teachers' assess their success. For example, Phoebe began a long reflection on what students learned from a lesson by saying they hadn't learned much, but after talking out loud about it for awhile, concluded that they may have learned more than she initially concluded, since she wasn't used to this way of teaching.

At each step as teachers move towards understanding and using reformed-oriented practices, they may deconstruct and reconstruct the interpretations they held of teaching, and of teaching episodes in the past. For the reforms to be successful, this process of interpretation and reinterpretation needs to strike a delicate balance. Teachers need enough knowledge of the reforms and dissatisfaction with their current mathematics teaching to see the need for change, but enough of a positive sense of teaching efficacy and efficacy beliefs regarding the future to sustain their motivation. Phoebe and Peggy had dissatisfaction with their practice, but may have needed more knowledge for their teaching to evolve further. Molly had motivation and a strong sense of efficacy, but may have also needed more knowledge of the reforms and more dissatisfaction, if her practice was to evolve more towards principled understanding of mathematics. Parallel to the effects of teaching efficacy beliefs on students, progress and learning are more likely if teachers believe that their own mathematics teaching efficacy can evolve, and believe they can help to make it evolve, alone or with others' help.

Shaping the Influence of Others

Of course, teachers may influence the feedback that they get from others, as indicated by the arrow going from "teachers' interpretations" to "influences on teachers' interpretations." For example, while Peggy's interpretations were influenced quite a bit by students' and parents' interpretations of what counted as meaningful mathematics to be learning, Molly actively shaped the perceptions of both students and parents regarding what mathematics was meaningful and worthwhile. By shaping their interpretations regarding meaningful effects, Molly modified the feedback she received from students, parents and others them regarding her efficacy.

The efficacy beliefs which teachers construct through the processes described above influence their planning, and the kind of teaching acts that they initiate and sustain.

Other Influences on Teacher Planning, Decisions, and Actions

Along with teachers' goals and efficacy beliefs, several other factors play important roles in teacher planning and decision making.

Teachers' knowledge of mathematics and of methods for teaching mathematics not only influences teachers' efficacy beliefs, but also teacher planning and action. Obviously, lack of knowledge in these areas limits teachers' options. For example, Peggy didn't seem to know about problem-solving strategies, or how to teach students a set of strategies with which they could solve problems.

Another influence on teachers' planning and actions is the level and kind of material resources available to them for teaching. Such an issue may seem mundane, but lack of resources can profoundly limit teacher experimentation and change. In the third year of the study, Phoebe decided not to try a number of lessons from the Math in Stride series, because she would have to pay for her own copy paper to do the lessons. A year later, in her last year of teaching, she was teaching lessons she had never taught before, and which were now feasible for her to do because of the endless supply of copy paper which the school had received that year.

A wide variety of other contextual influences, such as type of students and school context, also influence teachers' decisions and actions.

Of course, teachers may be proactive in shaping the conceptual resources and material resources available to them, and in shaping their own teaching context. This is suggested in my model by the arrow from "teachers' planning and actions" to "other influences on teachers' planning and actions." For example, all three teachers, to very different degrees, expanded their knowledge of mathematics teaching during the study. Molly collected and developed a wealth of teaching tools. Molly also influenced her own teaching context by spearheading the creation of the science lab and by getting parents to help her grade papers, and teach computation and art to students. All this freed her up to focus more on the aspects of mathematics she wanted to focus on. Thus, Molly helped develop both the social support system and the teaching resources that allowed her teach in the way that she wanted to teach.

Both resources and context affect teachers' decisions and actions through further influencing teachers' efficacy beliefs regarding future teaching. That is, teachers' efficacy beliefs are highly contextualized. The belief that one can have a certain effect on students in the future is informed and shaped by the knowledge and resources that the teacher believes will be available to her, and by the context in which she will be teaching.

Teacher Planning, Decisions, and Actions

Teacher planning, decision-making and classroom teaching are aspects of teaching represented by their own bodies of research. However, returning to this part of the model brings us to the point where the teachers' decisions and actions interact with the decisions and actions of students, parents and others, to create socially-created student outcomes.

One aspect of what happens at this step in the model is important to highlight, given the findings of this study. That is, teachers with an interpretation that teacher efficacy is created by the teacher acting alone are less likely to take full advantage of the social resources at their disposal. They are also less likely to help in the creation of social resources that can aid in the education of the children in their classroom. Those with a more interdependent interpretation of how efficacy is achieved will focus in part on setting into motion mutually beneficial cycles of interactions with students, parents, and others. With this interpretation, achieving the highest levels of teacher efficacy is believed to require moving away from trying to influence student outcomes on one's own.

Further Reflections on the Model

There are a few other points to emphasize regarding this model of teachers' efficacy beliefs.

It is important to note that this model is based upon research into teachers' efficacy beliefs regarding their teaching of mathematics. Somewhat different models may be more helpful for understanding teaching and learning of other subject matters. Also, this model stresses the importance of both intrapsychological processes (e.g., interpretation), and interpsychological processes (i.e., social process). Understanding the role of both sets of processes is necessary to have a thorough understanding of the development and influence of teachers' sense of efficacy and efficacy beliefs.

On the intrapsychological level, interpretation and re-interpretation play key roles in shaping teachers' sense of efficacy regarding past teaching, and their efficacy beliefs regarding current and future teaching. Also important are teachers' goals, knowledge, and a variety of beliefs regarding students and teaching.

On the interpsychological level are all of the social interactions that shape teachers' goals, knowledge, and their interpretations regarding their past, present, and future efficacy. In Vygotsky's terms, teachers have to "interiorize" a great deal of cultural information in order to teach in more reform-oriented ways, and to feel effective when doing so. Teachers can teach in reform-oriented ways (at least to a degree) but not feel effective with such teaching, unless they have also fully accepted the goals of the reforms, and internalized new ways of assessing student outcomes, and new ways of interpreting what they then learn about student outcomes. Achieving all of this a complicated problem, because the implications of the mathematics reforms extend beyond students' learning of new mathematics skills and knowledge. The reforms also suggest new ways in which teachers and students relate to one another, new ideas regarding how we should think about knowing a subject, and new ideas about fostering student independence and interdependence, rather than dependence on adults. Admittedly, not all of these ideas are "new" ideas for educational researchers and policymakers, but they have never been fully accepted in the nation's educational system. Policymakers need to help teachers learn how to assess and reinterpret student outcomes so that the outcomes associated with reformed teaching are more likely to result in a positive and evolving sense of efficacy and positive and evolving efficacy beliefs.

Also, this model suggests a broader and more complicated picture of what effective teaching really requires. The traditional uni-directional model of teacher efficacy, with the solitary teacher viewed as affecting student outcomes on their own is consistent with teaching by telling, but is also not consistent with the mathematics education reforms.

In this model, effective teaching also requires eliciting social support from others, and learning to make use of that assistance. Teachers also need to learn how to shape parents' and students' interpretations regarding effective mathematics teaching. Then they can establish with others a new intersubjectivity regarding effective mathematics teaching, with this new shared understanding being consistent with the purposes of the reforms. This reinterpretation regarding meaningful outcomes needs to encompass learning and motivational outcomes, and a view of teacher-student relationships in which increasing student independence and interdependence (and decreasing student dependence) are valued. To be effective in reformed mathematics teaching also requires acquiring and developing conceptual and material resources for teaching. Finally, it requires having a positive influence within one's teaching context, one that will then bear fruit for the teacher.

The Model and Directions for Research

Not surprisingly, the model resulting from this qualitative study suggests a qualitative change in the study of teachers' efficacy beliefs. It is still important to consider how effective teachers feel in teaching mathematics, and how effective they believe they can be in teaching mathematics, especially using reform-oriented teaching practices. However, this study and the resulting model of teachers' efficacy beliefs suggest focusing not only on how effective teachers believe they are, but on how they believe they are effective. Central to this is examining whether teachers' sense of efficacy regarding past teaching and their efficacy beliefs are based on interpretations of teaching efficacy as something that is independently achieved or whether they are based on an interpretation of interdependent teaching efficacy.

Chapter Six

LIMITATIONS AND IMPLICATIONS

Limitations of This Study

Was This Study a Faithful Account of the Teachers' Stories?

One question about this study is the degree to which I was able to accurately portray the story of each teacher, given my research focus. Case study research relies on the researchers' skill in collecting, analyzing, and interpreting data. I constructed these cases carefully, so that they would be fair and faithful accounts of the issues I was studying. In each case, I had different types of data for each teacher, data from different time periods, and data from different informants within the school. Having these various types of data, my own reflection and questioning, and my collaboration with colleagues regarding these cases, have all helped to ensure that what I have reported is a faithful account of each teacher. Nevertheless, there are factors that make it possible that these stories are not as faithful and representative accounts as they might be. Research design, data collection procedures, any lack of research skill on my part, along with my own biases, all make it possible that I didn't quite "get the story right."

Other Stories Could Have Been Told

Another question about this study has to do with the other stories that could be told about these teachers. Choosing a different research focus, or a different research design, or different methods for collecting data, all would have yielded different stories. What I report in this study are particular stories of these teachers, told from the particular perspective that I chose for the study. A story about Peggy with teacher knowledge at the center might provide more detailed accounts of her knowledge of specific reform-oriented teaching practices. A microgenetic study of motivational processes might have told of relationships between experiences, attributions, goals, and efficacy beliefs as they related to the use of a particular teaching method over time. Those would be useful stories as well, and would complement the stories that were reported here.

What is the Meaning of These Stories for Others?

A final question about this study has to do with the meaning of these stories for other teachers in other places and times, and for those who work with teachers. A particular strength of qualitative and interpretive research is its role in theory-building (Erickson, 1986). However, it is never clear how valuable the themes found in a few cases will be to others in different situations. As Erickson (1986) notes, progress is slow and gradual with this type of work. Progress requires looking for themes that appear across a variety of studies such as this one, in order to identify "concrete universals."

Implications of This Study

There are several implications of this study. This study suggests new directions for policymakers who are interested in the success of reform-oriented mathematics teaching. This study also suggests new directions for researchers interested in understanding teachers' efficacy beliefs.

Implications for Reform Efforts in Mathematics Education

There are three implications of this study for reformers in mathematics education.

Wanted: An Effective Role for Both Students and Teachers

This study suggests that it is important for reformers to clearly communicate to teachers about the ways in which students can be active in their own learning of mathematics and teachers can be active in helping students learn. In this study, only Molly and her students achieved this consistently. Children were gaining the mathematical power called for by the reforms, but Molly too had a great deal of power, or efficacy. Learning and teaching were both active, and interwoven.

For Peggy, moving towards mathematical power for students meant giving up her power. Students learned through discovery on their own, or from the peers who Peggy thought they understood better than they did adults. The 1992 California Mathematics Framework itself may have suggested this loss of agency or power for teachers. Giving up agency to a significant degree poses a direct threat to teachers' sense of efficacy, which is central to their motivation to teach, and the satisfaction that they derive from teaching. Such a threat to teachers' sense of efficacy in turn poses a clear threat to the success of the reforms.

On behalf of teachers like Peggy, reformers and reforms may need to make it clearer that active learning and active teaching can be interwoven, and need to make it clearer how they can be interwoven. Policy efforts in early childhood education (e.g., Bredekamp & Copple, 1997) have made this point very directly, by emphasizing the importance of <u>both</u> active learning <u>and</u> active teaching. Teacher efficacy may be <u>different</u> when teaching mathematics in reform-oriented ways. However, it may help teachers if the reforms make it clearer that teacher efficacy is still <u>possible</u>, and explain how it is possible.

<u>Teaching in the Zone of Proximal Development</u>

This study suggests that reformers carefully attend to how successful reformed mathematics practices are actually accomplished. At least in Molly's case, her practice was only possible because of a vast array of cultural tools and social supports. She sought out social supports and created social supports that would serve her teaching practice. However, she was not simply dependent on others, there were important interdependencies in her relationships with students, parents and others. There was a real synergy in the interactions between Molly and her students, and between students' motivation and their learning. Molly did not feel less effective because she required the help of others to teach the way she did. She felt more effective teaching this way.

Thus, this study suggests that effective mathematics teaching may not be accomplished alone, and perhaps should not be conceived of as the kind of task that one accomplishes alone. Such teaching is simply beyond one's current individual capacity, and is accomplished only with the substantial assistance of others. This suggests that reformers should communicate the point that reformed teaching is an activity that lies in one's zone of proximal development, and thus, requires others' help. Ideally, this takes the form of relationships characterized by positive interdependency, with students, with parents, with teachers, and with others.

Being Careful About How We "Motivate" Teachers

This study suggests the need for reformers to address more clearly the role of motivation in making reform-oriented mathematics teaching work. In particular, clearer attention is needed with regard to fostering intrinsic motivation and self-regulation in teachers and students alike.

A section under "Facilitating and supporting student learning" in the 1992 California Mathematics Framework notes that "teachers should continually reflect on questions like these: 'How can I structure the classroom environment and my interactions with students so that they want to confront and make sense of mathematics?' (p. 49)" In my experience, many teachers can entertain this question, but then conclude that they need to consistently use rewards to motivate students to learn mathematics. Peggy had thought for a long time about getting away from reliance on rewards, but knew little about any other system of motivation that she could rely on. We cannot expect teachers to reflect productively on the question above without better information. Many teachers have been taught, and believe, that they need to motivate students initially with rewards, and fade the rewards as children experience the "intrinsic rewards" of doing the task. Unfortunately, such use of extrinsic rewards can change the way children view the task and themselves, making continued use of extrinsic rewards to elicit motivation seemingly more necessary. Moreover, children engaging in tasks to get rewards sometimes do the task differently than when they are intrinsically motivated, and do it in a way so that they do not experience the task as "intrinsically rewarding" (Schwartz, 1982). Teachers need a different set of conceptual tools for approaching classroom motivation, besides punishments and rewards. The reforms need to help teachers understand how intrinsic motivation and self-regulation can be supported, or undermined.

This study suggests that reformers should reconsider their view that only a small percentage of teachers are "intrinsically motivated individuals" (Elmore, 1996, p. 314), and that lacking that intrinsic motivation, stronger external controls are needed to motivate teachers.

Rather than treating intrinsic motivation as an individual trait, reformers may be helped by receiving more information on intrinsic motivation and self-regulation, and reflecting on the application of this information. Reformers might ask themselves how they can help to structure the educational environment so that teachers will want to make sense of mathematics and mathematics teaching. Also, under what conditions will teachers come to value the goals of the reforms and believe that this approach works better? These questions are more in the spirit of the reforms themselves than are questions about how teachers can be motivated better through the use of extrinsic controls. Moreover, it is possible to foster synergy in the interactions among elementary teachers as they reflect on and change their mathematics teaching (Pourdavood & Fleener, 1997). However, it is difficult to achieve this synergy of motivation and learning if teachers' motivation to engage in learning about their teaching is extrinsically, rather than intrinsically motivated (R. Pourdavood, personal communication, June 5, 1997).

Implications for Research into Teachers' Efficacy Beliefs

There are three implications of this study for researchers who study teachers' efficacy beliefs.

Identifying New Supports for Feelings of Efficacy

This study suggests the need for more research into the ways in which teachers can come to feel effective when teaching in reform-oriented ways. Molly found a variety of reasons for feeling effective, but the results were more mixed or negative in the other two cases. Is a teacher like Peggy helped to feel effective if she begins by avoiding some of the more challenging elements in the reforms? What would happen if she focused first on students being creative with math, and working on problems for which there were multiple solutions or multiple solution paths? Would a teacher like Phoebe be helped by starting her use of reformed practices with something "practical" like teaching problem solving? How do teachers who succeed in adopting reform-oriented practices persist through periods when they feel less effective? Do they have to learn to reinterpret their own success and failure, and if so, how does that happen? What role does dynamic assessment play in supporting feelings of efficacy? How can change happen in teachers' beliefs regarding the impact of reformed mathematics teaching? These questions and others deserve attention in future research into teachers' efficacy beliefs.

The Need for More Qualitative Research in This Field

This study suggests the need for more research of a qualitative nature on teachers' efficacy beliefs, especially as they attempt reform-oriented teaching. In this study, the content of teachers' interpretations and explanations was important to understanding their successes and struggles, and the fate of reform-oriented mathematics teaching. A study using qualitative methods to research teachers' efficacy beliefs regarding science teaching also yielded interesting and potentially helpful findings regarding the reasons and interpretations of teachers who feel very efficacious and those who do not (Ramey-Gassert, Shroyer, & Staver, 1996). Teachers' motivation relies in part on their efficacy beliefs. These in turn rely in part on their interpretations of past teaching events and of the current teaching situation. Better understanding of how teachers progress toward reformed teaching requires better understanding of the ways in which teachers interpret the effectiveness of reform-oriented teaching practices.

Extending the Study of Teachers' Efficacy Beliefs

Finally, this study suggests that the research into teachers' efficacy beliefs needs to be extended. In general, this study suggests the need for further research into teachers' efficacy interpretations--not simply how effective they feel, but how they feel effective, and how they believe effectiveness is achieved. In this section, I discuss new conceptions regarding teachers' beliefs about educational efficacy and about teacher efficacy, and suggest first steps for research into these beliefs.

Researchers need to focus on teachers' efficacy beliefs when they interpret their teaching as being beyond their capacity to carry out alone, and as not being carried out alone. It is common to study students engaging in tasks in their zone of proximal development, but less common to study this phenomenon for teachers. Molly's teaching practice was in her zone of proximal development, but she was not simply dependent on others. She created and fostered systems of interdependency, and synergy was the result in her teaching.

How do teachers interpret themselves and their effectiveness when their practice works this way? How do they come to have these interpretations in a society that so often emphasizes accomplishments achieved alone? Researchers need to pay particular attention to teachers' beliefs regarding the social construction of educational efficacy, and the social construction of teacher efficacy. "Teacher efficacy" may be part of the equation in a teacher's beliefs. However, taking Molly's case, there was no way in which teacher efficacy could be neatly separated from the pattern of social interactions that shaped not only student outcomes, but shaped Molly and the parents as well. Where interactions surrounding education result in synergistic, rather than simply additive effects, we need to understand teachers' beliefs regarding the social construction of educational efficacy. Within this conception, a teachers' interpretation of a teacher's efficacy may partly consist of how the teacher sets in motion a synergistic pattern of interactions with and among students, with and among parents, and with and among teachers, administrators and others.

To study such feelings of efficacy requires a different perspective and different questions. The bulk of research into teachers' efficacy beliefs has emphasized what effect an individual teacher acting alone can accomplish. Some past research actually seems based on the premise of negative interdependency--that efficacy is a zero-sum affair. Thus, one questionnaire item used by Gibson and Dembo (1984) asks, "A teacher is very limited in what he/she can achieve because a student's home environment is a large influence on his/her achievement" (p. 581). Such a question makes sense from a traditional locus-of-control perspective, and makes sense given the emphasis in earlier research on whether teachers believed they could overcome the negative background of students from lower-SES families. However, it might not make sense to Molly, who might suggest instead that "A teacher can achieve a great deal because the students' home environment has a large influence on his/her achievement." That is efficacy achieved through positive interdependency.

This study suggests that future research should explore what teachers feel capable of accomplishing with the help of others, where they and others are interdependent, and where good teaching is viewed as a task that is beyond the capacity of a teacher to ever really do on her own. Needed are specific questions focused on how teachers conceive of the contributions of such interactions to educational efficacy. Also needed are questions about how these interactions influence the teacher's ability to take effective action and influence student outcomes. What does the teacher get out of her interactions with students, parents and others, and how does this cycle back into the educational process?

Researchers need to explore the degree to which teachers view various interdependent relationships as influencing student outcomes. Do teachers view these as negative or positive interdependencies? Some questions regarding teacher efficacy seem to assume negative interdependency between the influence parents have on student and the teachers' capacity to influence the student. Many questions in the teacher efficacy beliefs literature implicitly treat teacher efficacy as something constructed alone by the teacher. Under what conditions do teachers tend to construct and hold onto this independent interpretation of teacher efficacy? Under what conditions do teachers adopt an interpretation in which "their" efficacy is viewed as being socially constructed, and achieved through positive interdependent relationships with others? Under what conditions are students, parents, and principals able to adopt this interpretation--that teacher efficacy is socially constructed? Asking questions regarding the impact that teachers believe they can have "on their own," and they impact they believe they can have when working together with others is another way to approach this issue. Finally, for teachers who believe that true effectiveness is achieved by teaching in a way that is beyond their ability to do on their own, what are their efficacy beliefs regarding their capacity to engage others productively in such jointly-constructed teaching and learning?

APPENDIX

APPENDIX A

APPENDIX A

RESEARCH ON TEACHERS' EFFICACY BELIEFS

Roots of Teacher Efficacy Beliefs Research

The earliest ERIC citation using "teacher efficacy" is a 1974 study in which Barfield and Burlingame measured teacher efficacy using a political efficacy beliefs scale. However, the main roots for most research into teacher efficacy beliefs are Bandura's social learning theory (1977, 1982, 1986) and Rotter's social learning theory (1966).

Rotter's Influence and the Rand Studies

Rotter's social learning theory defined efficacy beliefs as generalized expectancies about whether outcomes are believed to be controlled by factors internal to the individual (i.e., "locus of control") or external to the individual (i.e., "external locus of control").

Efficacy beliefs first made a significant impact in educational research with the Rand "Change Agent" studies, in which teachers' sense of efficacy was based on Rotter's theory (Armor et al.,1976; Berman et al., 1977). In the Rand studies, teacher efficacy beliefs were defined as "the extent to which the teacher believes he or she has the capacity to affect student performance" (McLaughlin & Marsh, 1978, p. 84). Efficacy beliefs were measured by computing the total score from teachers' responses to two five-point Likert scale questionnaire items (rated highly agree to highly disagree):

> Rand item 1: When it comes right down to it, a teacher can't really can't do much, because most of a student's motivation and performance depends on his or her home environment.
>
> Rand item 2: If I try really hard, I can get through to even the most difficult or unmotivated students.

McLaughlin and Marsh noted that teachers' sense of efficacy was "the most powerful teacher attribute in the Rand analysis" (1978, p. 84). This was a major finding at the time, since previous efforts to find relationships between teacher attitudes and student achievement had yielded few results (Dunkin & Biddle, 1974; Getzels & Jackson, 1963).

General and Personal Teaching Efficacy

Much of the research in the 1980s was organized around the two dimensions of "general teaching efficacy" and "personal teaching efficacy" which were represented by the first and second Rand items, respectively. General teaching efficacy refers to the belief that teachers in general can impact learning and/or motivation, regardless of students' home environment. Personal teaching efficacy refers to an individual teacher's belief that she or he can impact the learning and/or motivation of students.

Early Conceptual Debates

Although several studies have combined the scores for the two constructs (e.g., Guskey, 1988), and the value of maintaining the separate constructs has been questioned (Smith, 1996) various findings have supported the conclusion that the dimensions of general teaching efficacy and personal teaching efficacy are distinct beliefs. A study by Ashton, Olejnik, Crocker, and McAuliffe (as cited in Ashton & Webb, 1986) found the two dimensions were not significantly correlated. Hoy and Woolfolk (1990) found that the two constructs change in opposite directions in certain contexts, while Woolfolk and Hoy (1990) found them to be related in opposite ways to teachers' bureaucratic orientation. In several studies (Gibson & Dembo, 1984; Enochs & Riggs, 1990; Enochs, Riggs, & Ellis, 1993), factor analysis found the two factors to be distinct. Finally, Hoy and Woolfolk (1993) reported on different antecedents of the two forms of efficacy beliefs, and only a weak relationship between the two.

Dembo and Gibson (1985) questioned whether a general component of personal efficacy (general teaching efficacy) is essential to a model of teacher efficacy, since Bandura (1977) maintained that self-efficacy is by definition situation-specific, and cannot be identified in general terms. However, others suggest that a teacher's general teaching efficacy beliefs may influence the effects of negative personal teaching efficacy beliefs on one's feelings and self-appraisal. That is, the effect of feeling that you cannot impact students may be very different if you believed that no teacher could do so, as compared to if you believed that most teachers could.

Clearer Connections to Bandura's Theory

Following the Rand studies, there was a significant increase in research into teacher efficacy beliefs, with Patricia Ashton and her colleagues playing a major role. The field moved toward greater reliance on Bandura's social learning theory as a better explanatory framework for the research (Ashton & Webb, 1986).

Bandura defined self-efficacy beliefs as "judgments of how well one can execute causes of actions required to deal with prospective situations" (1982, p. 122). This broad sense of one's sense of self-efficacy relies on two types of beliefs--outcome expectancies and efficacy expectancies (1977). Outcome expectancies refer to beliefs about what results are caused by a certain act or actions in a specific situation. Efficacy expectations are the individual's belief in their own capacity carry out that act or those actions in that situation.

Unfortunately, Bandura and others (e.g., Borchers, Shroyer, & Enochs, 1992) sometimes use "self-efficacy" to imply the broader capacity to take effective action, and sometimes also use the term "self-efficacy beliefs" to refer to the narrower beliefs described above under "efficacy expectancies." For example, Borchers et al. (1992) use the term self-efficacy beliefs to refer to the broader sense of one's beliefs about one's own efficacy and also use it to refer to the more specific beliefs that are one of the two subcomponents of the broader sense of "self-efficacy beliefs." Needless to say, such usage can be confusing.

Efficacy expectancies (a.k.a. "self-efficacy beliefs") and outcome expectancies often have different functions and effects, as found in recent research in elementary science teaching (Ramey-Gassert et al., 1996).

Influences on Efficacy Beliefs

Bandura (1976, 1982) suggests that there are four sources of influences on self-efficacy beliefs: performance accomplishments, vicarious experiences, persuasion, and interpretation of one's own physiological states. Performance accomplishments refer to the fact that objective successes and failures, and our interpretations of the reasons for those outcomes, influence our efficacy beliefs. Bandura (1977) notes that successes and failures are not unambiguous sources of efficacy information--as there are many possible causes of outcomes. Thus, the causal attributions we make for success and failure influence our subsequent efficacy beliefs (Schunk, 1994). Vicarious experience refers to the process of observing someone performing an act. This process may then influence efficacy beliefs (e.g., "If he can do it, so can I"). Persuasion by others can also influence efficacy beliefs, although its effects are often short-lived if not accompanied by actual successes. Monitoring physiological states, and reflecting about them, also influences efficacy beliefs. Physiological arousal that is interpreted as anxiety in the face of an impending task can undermine efficacy beliefs.

"Cognitive appraisal" in judging information about efficacy plays an important role. Thus, performance accomplishments may not improve our efficacy beliefs if they are followed by external attributions of the causes for our success. Seeing others model a particular course of action can also improve our perceived self-efficacy, particularly if the model is similar to us in ability. However, such modeling may have no effect on efficacy beliefs if we attribute the model's success to their possession of a higher of skill than we possess. Persuasion by others aimed at changing our efficacy beliefs can also be discounted, for example, if we believe that the person attempting to persuade us isn't credible, perhaps because they lack knowledge of the demands of our situation.

It is important to remember that Bandura's theory assumes bi-directional causality. As Berry (1989) explains: "The model assumes that self-knowledge of abilities derives from, yet also determines, behavior in a dynamic and mutually reciprocal developmental process" (p. 683). Thus, teachers' efficacy beliefs and other related variables like student achievement are believed to affect each other reciprocally (Ashton, 1985). Bandura's model is deterministic, and thus there is a "reciprocal determinism" played out between effects of the environment and internal human factors, as they act as "interlocking determinants of each other" (Ashton, 1985, pp. 144-145).

How Do Self-Efficacy Beliefs Work?

In Bandura's theory, self-efficacy beliefs are believed to have a broad role in human functioning:

> It is partly on the basis of judgments of personal efficacy that people choose what to do, how much effort to invest in activities and how long to persevere in the face of obstacles and failure experiences. People's judgments of their capabilities additionally influence whether their thought patterns are self-hindering or self-enhancing, and how much stress and despondency they experience during anticipatory and actual transactions with the environment. (1989, p. 42)

Setting Goals

Bandura and Cervone (1983) suggested that one role of efficacy beliefs is to mediate between an individual's goal systems and performance motivation. In other words, we are more likely to pursue those goals that we believe we can achieve. Bandura (1989) notes that cognitive representation of future events converts conceived future events into motivators and regulators of behavior: "Personal goal setting is influenced by self-appraisal of capabilities. The stronger the perceived self-efficacy, the higher the goals that people set for themselves and the firmer their commitment to those goals" (p. 730).

Research has supported the theory that perceived self-efficacy affected "the level of self-set goals, strength of goal commitment, and level of cognitive performance" (Bandura, 1989, p. 1026). Studies by Locke, Shaw, Saari, and Latham (1981) and by Mento, Steel, and Karren (as cited in Bandura, 1989) indicate that adopting challenging goals raises the level of motivation and performance attainments.

Bandura (1989) suggests "There is a difference between possessing skills and being able to use them effectively and consistently under varied circumstances" (p. 733).

When compared with people with low efficacy beliefs regarding their performance in a given situation, people with high efficacy beliefs are more likely to mobilize and use the skills and knowledge they have when in a performance situation, and are more likely to persist when faced with failure (Bandura, 1986). Schunk (1990) noted that motivation and efficacy are interacting mechanisms. Pintrich and DeGroot (1990) suggest that "efficacy may indirectly influence performance through its effect on strategy use" (p. 4).

People with a resilient sense of efficacy tend to ascribe failure to lack of effort, heighten effort in the face of failure, and process information more actively than those with negative efficacy beliefs (Bandura, 1989). In contrast, people who doubt their capabilities shy away from difficult tasks. They have lower aspirations and weak commitment to the goals that they choose to pursue. In taxing situations, they dwell on their personal deficiencies, the formidableness of the task, and the adverse consequences of failure (Bandura, 1989).

Dissatisfaction combines with self-efficacy beliefs in important ways. Bandura and Cervone (1983) note that "It is postulated that self-dissatisfaction and perceived self-efficacy jointly determine performance changes" (p. 1023). In a study of college students' performance on a physical task, they found huge performance gains for subjects who were both self-dissatisfied but highly efficacious, and noted that "Perceived self-efficacy is also predictive of the performance changes exhibited by subjects who had the benefit of goals and feedback" (p. 1022). They concluded that when dissatisfaction with past performance combines with self-efficaciousness, people mobilize effort to master the challenge.

One still might wonder why efficacy beliefs are related to performance in the ways noted above. Bandura (1989) notes how people with a high sense of efficacy visualize success, and these visualizations guide their efforts. Also, he says that people who believe that they can manage potentially challenging or stressful situations do not conjure up apprehensive thoughts and, thus, are not perturbed by them.

People with low efficacy beliefs in a given situation visualize failure scenarios and imagine how things will go wrong. Bandura (1989) notes that "Such inefficacious thinking weakens motivation and undermines performance" (p. 729). Such thinking diverts people's attention from thinking about how to best execute tasks, and leaves them dwelling on personal shortcomings and possible disasters. Citing related research, Bandura (1989) concluded: "Through ruminative inefficacious thought, people depress and distress themselves and constrain and impair their level of functioning."

In social learning theory, efficacy beliefs influence one's reaction to potentially threatening situations, and both anxiety and defensive behaviors are considered to be co-effects of low efficacy beliefs in such situations (Bandura, 1977). The negative feelings that accompany negative efficacy beliefs can prevent or interfere with performance--even in people who have generally succeeded at a task, as judged by objective measures (Bandura, 1982). Not surprisingly, those who believe that they cannot exercise control over stressors in challenging situations experience high levels of subjective distress, and measurable physiological changes associated with their resultant anxiety.

Along with attributions and goals, efficacy beliefs play an important role in theories of motivation generally, such as the social cognitive theory of self-regulation (Schunk & Zimmerman, 1994).

Efficacy beliefs can be changed, at least in some situations. For example, Bandura was successful changing individual's efficacy beliefs regarding their snake phobias. He notes "After perceived coping efficacy is strengthened to the maximal level, coping with the previously intimidating tasks no longer elicits differential stress reactions" (Bandura, 1989, p. 730).

However, Bandura (1977) notes that negative beliefs also serve self-protective functions, and are not easily discarded. Low efficacy beliefs can protect the individual from attempting tasks and experiencing actual failure. Thus, negative outcome expectations can protect individuals from harmful interpretations of actual failures--if people in general can't make something happen, then one's own failure takes on a less negative tone.

Remaining Confusion over Efficacy Beliefs

Some confusion is to be expected in a field where various beliefs of teachers are routinely written about as "teacher efficacy." I found at least eleven different beliefs that have been studied in the field, without even counting beliefs about one's efficacy with regards to specific aspects of teaching, subject matter areas, or types of student. It is often difficult to tell how efficacy beliefs are being conceptualized or studied, such as when researchers using the Rand questionnaire items have incorrectly identified general teaching efficacy as being an outcome expectancy consistent with Bandura's theory (e.g., Benz, Bradley, Alderman, & Flowers, 1992; Coladarci, 1992; Gibson & Dembo, 1984).

Since different beliefs are sometimes related in very different ways to variables of interest, I had great difficulty knowing what to make of the discussion when writers whose scales don't appear in their articles discuss how they studied teacher efficacy or teacher efficacy beliefs. Thus, I agree with the comment by Woolfolk and Hoy: "At best the notion of teacher efficacy is complex; at worst it is confused" (1990, p. 81). Fortunately, some of the more recent research has been more careful about definitions and connections to theory, and research in this area has been quite productive despite the varied definitions currently in use.

Influences on Teachers' Efficacy Beliefs

Bandura's (1977) view that efficacy beliefs are context-specific in nature has been echoed by many efficacy beliefs researchers (Ashton, 1985; Ashton & Webb, 1986; Dembo & Gibson, 1985; Enochs, Riggs, & Ellis, 1993; Gibson & Dembo, 1984; Raudenbush, Rowan, & Cheong, 1992). Given this assumption, one would predict significant variation in any individual teacher's efficacy beliefs, depending on context. Indeed, using hierarchical linear modeling to study teachers' efficacy beliefs, Raudenbush et al. (1992) found that forty-four percent of the total variation in teacher efficacy beliefs in their study was intrateacher variation, which they felt confirmed their expectations that "perceived self-efficacy has a large contextually situated component" (p. 158).

So, what influences teachers' varying feelings of efficacy? I first examine characteristics of teaching itself, and then some of the research findings on the issue.

The Nature of Teaching

First, it is difficult for teachers to assess their actual impact with any uncertainty. Denham and Michael (1981) note "In an educational setting, it is often not clear whether a teacher's experiences have been successes, failures, or a combination of successes and failures" (p. 44). Also, the goals of teaching are often vaguely defined and conflicting (Lieberman & L. Miller, 1991). Measurement of learning is an uncertain affair--debates continue to rage on about the meaning, relevance, and validity of various ways of assessing student learning. Teachers rarely get feedback from others regarding their teaching and their impact (Lieberman & L. Miller, 1991), and when there is some clear evidence of student growth, it is not always clear how much credit the teacher can take for facilitating this growth (Lortie, 1975).

Second, teaching is an art--a messy one (Lieberman and L. Miller, 1991), meaning that the teaching-learning links are inherently uncertain, which can translate into low or tentative outcome expectancies.

Third, there are dilemmas inherent in teaching, in that teachers always face multiple and conflicting goals, and not being able to accomplish them all, teachers have to choose between them (Ball, 1993; Shulman, 1983). This situation gives teachers discretion over which goals to pursue (Shulman, 1983), but also means teachers are forever choosing aims that may make them feel more efficacious about one outcome at the expense of feeling less efficacious about another. For example, as Lieberman and L. Miller (1991) note, teachers are often judged first by others on whether or not they control their class. Thus, if there is tension between reaching the goal of classroom control versus the goal of learning, gains in one area may come at the expense of the other. The lack of clarity about goals and means of assessing them might make efficacy beliefs less salient than they are for tasks that are better defined.

Fourth, teachers tend to be private about their teaching, and promote this privacy in others (Lieberman & L. Miller, 1991; Lortie, 1975). Remaining private about one's teaching, and one's uncertainties about it, may protect feelings of efficacy in the short run. However, it may undermine feelings of efficacy in the long run, both by limiting possible affirming feedback, and by limiting opportunities to grow professionally through collaboration (Lieberman & L. Miller, 1991; Little, 1982).

Combining the dilemmas about educational goals to pursue with the lack of professional support teachers often experience, and the complex context of teaching, and as Lieberman and L. Miller (1991) note, teachers can't do what they know is best, they only can do the best they can under the circumstances.

Moreover, Ashton (1985) suggests a cultural belief regarding learners and learning that is a powerful influence on teachers' sense of efficacy:

> That is, as Bloom (1978) and Sarason (1971) have argued, the popular conception of learning ability as a stable trait varying widely among individuals provides teachers with an easy explanation for student failure that absolves them of responsibility for the failure. (p. 153)

Research on Specific Contextual Influences

I review here a few of the contextual factors that may influence teachers' efficacy beliefs. Although most of the work below is correlational, efficacy beliefs were viewed here as the dependent variable.

Consistent with Bandura's theory, Sparks (1988) found that teachers who improved in the skills being taught in workshops subsequently showed growth in self-efficacy beliefs. Less positively, Ramey-Gassert et al. (1996) found negative science outcome expectancies for elementary teachers who had negative experiences themselves in science or in science teaching.

Using hierarchical linear modeling, Raudenbush et al. (1992) studied several variables as they related to the efficacy beliefs of high school teachers. They found significant intra-teacher variability in self-efficacy by academic track (i.e., higher efficacy beliefs with college preparatory courses), by feeling prepared, and by student engagement. The track effects were most pronounced for math and science, less so for social studies, and tended to disappear when student engagement was controlled for.

Other factors positively correlated with high teacher efficacy beliefs include strong principal leadership (Edmonds, 1979; Ellett & Walberg, 1979; Hoy & Woolfolk, 1993), and high academic expectations (Brookover et al., 1978; Hoy & Woolfolk, 1993). Teacher experience and educational level were also found to be significantly and positively related to personal teaching efficacy (Hoy & Woolfolk, 1993). Hoy and Woolfolk (1993) also suggest that overall organizational health, and "aspects of school climate that help teachers accomplish their goals, may be related to teachers' sense of general and personal teaching efficacy" (pp. 360-361). Raudenbush et al. (1992) found that those teachers who reported greater control over instructional conditions and higher levels of staff collaboration also reported higher average levels of perceived self-efficacy. They note that these factors may not cause higher efficacy beliefs--they may just elaborate our image of an effective teacher.

Related to this, Fuller et al. (1982) point out that organizational efficacy--one's capacity to have influence within the school--may contribute to personal teaching efficacy beliefs.

Collaboration is a significant theme in this literature. Ashton (1984) notes that lack of collaboration and collegial decision-making puts teachers' sense of efficacy at risk. Others find teachers' efficacy beliefs to be related to teachers' interactions with other teachers regarding instruction (Ramey-Gassert et al., 1996; Smylie, 1988), and positive collegial relations more generally (Little, 1982; Meyer & Cohen, 1971). As Rosenholtz and Smylie (1984) note, such collegial relations are key to on-going skill development in teachers, which, in turn, fosters feelings of efficacy.

Newman et al. (1989) suggest that student ability is a powerful predictor of teacher efficacy beliefs, but they found that "when organizational variables are added to the prediction, student ability and other background variables lose much of their predictive power" (p. 368).

Finally, while there have been some conflicting findings regarding experience and teachers' efficacy beliefs, Hoy and Woolfolk (1993) found that teaching experience was positively related to personal teaching efficacy and negatively related to general teaching efficacy.

Teachers' Efficacy Beliefs and Teaching Practices

Calling teachers' sense of efficacy "a critical construct in explaining teacher motivation," Ashton (1985, p. 144) noted how teachers' efficacy beliefs are believed to influence teachers' choice of instructional activities, the effort they put into teaching, and their persistence when faced with difficulties.

Rosenholtz (1989) also explains that high efficacy and low efficacy tend to be self-fulfilling prophecies, thus resulting in very different student outcomes. Simply, teachers who don't believe something can be done are less likely to try to do it, while those who believe it can be done are more likely to try, to persist, and to get it done.

Indeed, teachers' efficacy beliefs are among the rare aspects of teachers' mental lives that have consistently correlated with various important educational outcomes (Woolfolk & Hoy, 1990).

While most studies are correlational, efficacy beliefs have generally been viewed in this line of research as the independent or mediating variable. I review below findings of studies that examined relationships between efficacy beliefs and teaching strategies, or other outcomes of interest.

Teaching Strategies

Efficacy beliefs have been found to be correlated to a number of teaching behaviors. In one study, teachers with positive efficacy beliefs spent more time in whole-class instruction than did teachers with lower efficacy beliefs (Gibson & Dembo, 1984). Interestingly, in a 1990 study by Dutton, comparing use of whole-group instruction versus cooperative learning, teachers with more positive efficacy beliefs were likely to use more cooperative learning and less likely to use whole-group instruction than teachers with more negative efficacy beliefs (as cited in Ross, 1995). Gibson and Dembo (1984) found that teachers with more positive efficacy beliefs spent more time monitoring and checking seatwork. In feedback to students following incorrect responses, teachers with negative efficacy beliefs were more likely to give answers, ask other students, criticize students, or allow other students to call out before the student gave the correct response, than were teachers with positive efficacy beliefs (Gibson & Dembo, 1984).

In a 1987 study of primary-grade teachers, P. S. Miller (as cited in P. S. Miller, 1991) found that as compared to teachers rated low in efficacy beliefs, teachers rated high in efficacy beliefs were more able to articulate the strategies they used to succeed in teaching low achievers. That is, teachers with more positive efficacy beliefs gave more explicit descriptions of effective methods and alternative strategies to use with low achievers. Also, as compared with teachers with more negative efficacy beliefs, P. S. Miller found that teachers with high efficacy beliefs described a greater variety and number of teaching strategies overall, and spent more time in instructional planning outside of school.

A qualitative study of elementary teachers' teaching of science and efficacy beliefs found that teachers with negative outcome expectancies in science were frustrated with the time students took to achieve understanding through hands-on science activities (Ramey-Gassert et al., 1996). These teachers felt that learning science for understanding was beyond their students, and used the prescribed scope and sequence. These teachers were also characterized by having had negative experiences with science and science teaching.

Pupil Control

Ashton and Webb (1986) found that secondary school teachers with negative general and personal teaching efficacy beliefs tended to interpret classroom interactions as matters of conflict and control, and used punishment, coercion, and public embarrassment. Those teachers with more positive efficacy beliefs had classrooms that were more relaxed and friendly, with less misbehavior, and the teachers seemed more trusting of students and handled misbehavior in more positive ways. Woolfolk and Hoy (1990) also reported that teachers with a low sense of general and personal efficacy were less humanistic in their beliefs about controlling students than were teachers high in both forms of efficacy, and also tended to use harsh, punitive management strategies.

Woolfolk et al. (1990) found that the more teachers believed that teaching could overcome the negative impact of the home environment (high general efficacy beliefs), the less they were custodial in their orientation to managing students, and the more they were "encouraging of student autonomy in problem-solving" (p. 143).

Negative efficacy beliefs and a more controlling orientation seem to be part of a pattern of beliefs that also includes different beliefs about students, particularly low-achieving ones. As P. S. Miller (1991) reported:

> Teachers with high efficacy scores used more positive and more academically-oriented language when describing low achievers or difficult learners, and saw these students as wanting to learn and capable of learning. Low efficacy score teachers described these students as having "low motivation, uncaring attitudes, lazy," and coming from parents who "don't care." (p. 33)

Student Outcomes

Teachers' sense of efficacy has also been found to be related to student achievement (Armor et al., 1976; Rutter, Maugham, Mortimore, Ouston, & Smith, 1979), and to student motivation (Midgley, Feldlaufer, & Eccles, 1989; Woolfolk et al., 1990).

In a longitudinal study of students making the transition to junior high school, Midgley et al. (1989) found that lower teacher efficacy beliefs were associated with lower student expectancies of their performance, and more negative student beliefs about their performance. They also found that low teacher efficacy beliefs were associated with student views of math as being harder as a subject--as compared with the beliefs and views of students whose teachers had higher efficacy beliefs. Students whose teachers had lower efficacy beliefs ... "lowered their expectancies and perceptions of their performance and raised their perceptions of the difficulty of math during the school year more than did students whose teachers felt more efficacious (p. 251)."

Midgley et al. (1989) also found that differences in teachers' efficacy beliefs tended to not have these effects on high achieving students, but had these effects were pronounced for low-achieving students. They suggested that this may be because lower-achieving students have a more external locus of control, and thus are more influenced by their teachers' efficacy beliefs.

Other Factors Correlated to Teachers' Efficacy Beliefs

Teacher efficacy beliefs have also been related to a variety of other teacher factors of interest. High teacher efficacy beliefs have been found to be positively related to superintendents' ratings of teacher competence (Trentham, Silvern, & Brogdon, 1985), teachers' satisfaction with teaching as a career (Trentham et al., 1985), teachers' commitment to teaching (Coladarci, 1992). They have also been found to be negatively related to teachers' stress levels (Greenwood, Olejnik, & Parkay, 1990) and leaving the teaching profession (Glickman & Tamashiro, 1982). Glickman and Tamashiro suggest that the lack of perceived impact among teachers with negative efficacy beliefs may be an important reason for leaving the profession.

Finally, efficacy beliefs have also been linked to referral of students to special education, with teachers with high efficacy scores referring fewer students to special education than did teachers with lower self-efficacy scores (e.g., Podell & Soodak, 1993).

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