LOOKING FOR CHANGE IN TEACHING PRACTICE IN A MATHEMATICS CURRICULUM INNOVATION PROJECT: THREE CASE STUDIES

DISSERTATION

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1994
To Diane, Gina, Kathy, and Teachers Everywhere
Who Are Seeking Ways
To Best Meet the Needs of Their Students
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# TABLE OF CONTENTS

DEDICATION .............................................. ii

ACKNOWLEDGMENTS ........................................ iii

VITA ......................................................... iv

LIST OF TABLES ........................................... vii

LIST OF FIGURES .......................................... viii

CHAPTER ..................................................... PAGE

I. INTRODUCTION AND BACKGROUND ........................ 1
   Background ........................................... 3
   Research Questions ................................... 5

II. A THEORETICAL FRAMEWORK ............................ 6
    A Constructivist View of Teaching and Learning .... 6
    An Extension of the Model ......................... 13

III. THE RELATED LITERATURE ............................. 16
    Pervasive Themes ................................... 16
    Toward a Constructivist Model ..................... 22
    Constraints to Change ................................ 24
    Ownership and Making a Difference ................. 26
    Constructivist Models of Teacher Change ........... 27
    A Revised Model ..................................... 32

IV. RESEARCH DESIGN AND METHODOLOGY ................. 34
    Toward a Research Methodology .................... 34
    Design of the Pilot Study .......................... 40
    Design of the Main Study ......................... 42
    Data Analysis ....................................... 45
    The Researcher ...................................... 50
    Conclusion .......................................... 53
V. THE CASE STUDIES ................................. 54
   The Case of Diane ........................................ 54
   The Case of Gina ......................................... 82
   The Case of Kathy ....................................... 106
   Understanding Differences in the Case of Kathy ....... 121
   Summary .................................................. 133

VI. DISCUSSION OF THE INTERPRETATIONS AND FINDINGS ........................................ 136
   The Research Questions .................................. 136
   Major Findings ......................................... 143
   An Evolving Model ..................................... 151
   Implications for Further Research .................... 156
   Conclusion .............................................. 158

APPENDICES

A. Diane's Survey Responses .......................... 159
B. Gina's Survey Responses ............................ 163
C. Kathy's Survey Responses ........................... 167
D. Teacher Beliefs Survey (June 1992) - Analysis ... 171
E. Interview Guides - Pilot Study ...................... 177

LIST OF REFERENCES ..................................... 186
# LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Teacher participant's descriptors of mathematics and the process of mathematics learning and teaching</td>
<td>125</td>
</tr>
<tr>
<td>2. A Cross-Case Comparison of Interpretations and Findings</td>
<td>135</td>
</tr>
<tr>
<td>3. Features of UCSMP Texts That Enabled or Inhibited Change</td>
<td>146</td>
</tr>
<tr>
<td>4. Summary Statistics By Question</td>
<td>171</td>
</tr>
<tr>
<td>5. Frequencies Of Each Response By Question</td>
<td>173</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A Cyclic Model of the Construction of Knowledge</td>
<td>12</td>
</tr>
<tr>
<td>2. A Cyclic Model of Teacher Change</td>
<td>15</td>
</tr>
<tr>
<td>3. Peripheral Factors in the Cyclic Process of Teacher Change</td>
<td>33</td>
</tr>
<tr>
<td>4. Teacher Change as a Reflective Cycle</td>
<td>151</td>
</tr>
<tr>
<td>5. From Perturbation to Change - A Reflective Turn</td>
<td>153</td>
</tr>
<tr>
<td>That Adapts Shaw and Jakubowski's Cognitive Requisites for Change into the Model</td>
<td></td>
</tr>
<tr>
<td>6. Teacher Change as a Reflective Cycle Based on Beliefs</td>
<td>154</td>
</tr>
<tr>
<td>7. Edwards' Model of Teacher Change</td>
<td>155</td>
</tr>
</tbody>
</table>
CHAPTER I
INTRODUCTION AND BACKGROUND

"A man is a small thing, and the night is very large and full of wonders."
- Lord Dunsany, quoted in Paulos (1988, p.177)

A critical problem facing mathematics education today is the translation of the vision of mathematics teaching and learning contained in the two National Council of Teachers of Mathematics (NCTM) standards documents (NCTM, 1989, 1991) into actual practice in our schools. This vision suggests learning environments that are quite different from the lecture-dominated norm that exists today (Goldsmith & Schifter, 1993; Hart, 1991; NCTM, 1991). Clearly some of what Richardson terms "significant and worthwhile changes" in mathematics teachers will be a necessary condition for the realization of that vision (NCTM, 1991; Richardson, 1990). Moreover, "as teachers implement important, timely, and exciting changes, they will require continuing programs of professional support" (Mathematical Sciences Education Board [MSEB], 1990, p. 48).

Ball and McDiarmid (1988) provide a more general rationale for investigating teacher change. They assert that knowing how teachers learn to teach requires a knowledge of how teachers' knowledge bases, skills, dispositions and the interactions among these factors change over time. At the same time, Shavelson and Stern (1981) indicate a need for research that links teachers' intentions and their teaching behavior,
noting that one justification for such research is the development of "... a sound basis for educating teachers and implementing educational innovations" (pp. 455-456).

MSEB (1990) sees change in mathematics education as an amalgam of many factors, suggesting that, "to improve mathematics education, change must occur simultaneously in curriculum, in teaching, in professional development, in textbooks, and in assessment practices" (p. 48). If this assertion is correct, then an attempt to study changes in teaching practice that occur when teachers implement innovative curricula and textbooks would provide valuable information about the process of teacher change. As Olson and Eaton (1987) have observed,

Curriculum projects have the often unintended but beneficial effect of asking teachers to reflect upon their practice in a critical way, because, while the materials may have been set up to accomplish certain learning outcomes, working with the materials also affects the way teachers think about their work. We should study those effects of curriculum projects as well as student achievements. (p. 180)

Nelson (1993), in examining the implications of research on teacher change for the professional development of teachers of mathematics, suggests a number of questions for which answers remain opaque. Among these are the role played by colleagues and supervisors in the change process, as well as that played by innovative curricula.

This study will investigate the conditions under which and the means by which worthwhile change in mathematics teachers' practices can be effected. In particular, the notion that such change can and will be facilitated by an innovative curriculum will be placed in the context of recent research in the area of teacher change.
Background

In the 1989-90 school year, a pilot project was conducted in the public schools of a large eastern city which introduced the University of Chicago School Mathematics Project (UCSMP) *Transition Mathematics* curriculum and textbook materials into the seventh and eighth grade mathematics classes of three teachers. A total of six classes in a single school were involved in the initial project. The researcher was one of those pilot teachers.

The three teachers in the pilot project shared a common preparation period, and they met weekly during the school year. At these meetings, the teachers discussed the UCSMP materials that they were using, their reactions to those materials, their students' reactions to those materials, what "worked" and what did not, and so forth.

For the 1990-91 school year, the UCSMP pilot in this district was expanded to include fifteen teachers in six schools. A total of nearly 500 students in grades 7, 8, and 9 were involved. The textbooks and materials used were *Transition Mathematics* (Usiskin et al., 1992) in grade 8, *Algebra* (McConnell et al., 1990) in grade 9, and *Geometry* (Coxford, Usiskin, & Hirschhorn, 1991) in grade 10.

During the second year of the project, all of the project teachers met as a group monthly during the school year. These meetings were organized and supported by the district's Director of Mathematics. She attended all of the meetings and frequently visited with project teachers in their respective schools. In addition, some of the project teachers exchanged telephone numbers and frequently shared ideas via that medium.
One cannot help but conjecture that these pilot teachers were regularly brought to the point of reflective activity regarding their practice. One also supposes that the Director's active support of her teachers helped to validate in their minds the worth of their efforts. Finally, one might wonder to what extent these pilot teachers' practices changed in response to the implementation of the innovative UCSMP materials in their classrooms.

During the 1991-92 school year, the UCSMP pilot project in this district was again expanded to include a total of 31 teachers in 11 schools and nearly 1,000 students. Approval was also granted for the district-wide implementation of the UCSMP materials in 1992-93. In the spring of 1992, in consultation with the Director of Mathematics, the researcher selected for case study one of the teachers who would be using the UCSMP materials for the first time during the 1992-93 school year. The study of this teacher served as a pilot for the main study.

During the 1993-94 school year, again in consultation with the Director of Mathematics, the researcher identified for case study two teachers who would be implementing UCSMP courses that year for the first time. The case study of the teacher from the pilot study was also extended to a second year.
Research Questions

UCSMP has developed an example of a secondary textbook series that incorporates much of the vision of the NCTM Standards (UCSMP, 1990). The UCSMP implementation in this district raises several important questions:

- When an innovative curriculum such as UCSMP is implemented by three experienced secondary mathematics teachers in a large urban school district, what changes do those teachers make in their instructional practices?
- If such changes do occur, to what might they be attributed? In particular, do other teachers and administrative support, as well as the innovative curriculum materials themselves, play a role in the process of change?

Finally, this study followed one of the teachers over the course of two consecutive school years. What were the similarities and differences in the process of change in this teacher's classroom practices over those two years? In particular, did this teacher exhibit more or less evidence of change in practice during the second year of the study vis-à-vis the first year of the study?
CHAPTER II
A THEORETICAL FRAMEWORK

"To understand is to invent."

- Jean Piaget (1948)

"The first problem is to show how the individual response emerges from the forms of collective life."

- Lev Vygotsky (1978, p. 59)

A current theoretical viewpoint that seems ubiquitous in mathematics education is constructivism: the theory that learners actively construct their own knowledge through interaction with their environment. If teachers are viewed as reflective thinkers who use a problem-solving approach to instructional practice, then such a cognitive theory can be extended to provide a theoretical framework for the study of teacher change.

A Constructivist View of Teaching and Learning

As it is with any philosophical point of view, there are differences, sometimes important ones, in the ways in which different educators who would label themselves "constructivist" view the teaching/learning process. It is the similarities, however, which characterize this viewpoint. Noddings (1990), believes that most constructivists would agree on the following:

1. All knowledge is actively constructed.

2. Knowledge is organized in networks that are increasingly more complex and abstract.
3. Constructed knowledge is under a nearly continuous state of reorganization and restructuring.

4. The construction of knowledge occurs at least partly as a reflective activity in an attempt to make experience meaningful.

It seems reasonable, therefore, to organize a theoretical framework around these four points.

*All Knowledge Is Actively Constructed*

A unifying theme in many contemporary theories of learning is that knowledge and cognitive structures are actively constructed by learners (Cobb, 1988). This belief is derived directly from Piaget's work. Note his stress on the learner's active construction in describing mathematical learning:

Mathematics is, first of all and most importantly, actions exercised on things, and the operations themselves are more actions, but well coordinated among themselves and only imagined instead of materially executed. Without a doubt it is necessary to reach abstraction, and this is even natural in all areas during the mental development of adolescence, but abstraction is only a sort of trickery and deflection of the mind if it doesn't constitute the crowning stage of a series of uninterrupted concrete actions. (Piaget, 1948, p. 103)

If, in fact, understanding is an invention of the mind, it follows that understanding, the lifeblood of knowledge, must be constructed. This construction cannot be passive; it must be active on the part of the learner. Resnick (1987) has noted that recent research implies that, in the case of mathematics, successful learners understand that the real task to be done is to construct meaning. Schoenfeld (1988) suggests that the presentation of subject matter as routine exercises to be "worked-out" in the absence of context or significant understanding renders the subject matter insignificant and meaningless, depriving students of the opportunity to understand what they have studied.
Skemp (1987) has built a powerful analogy between the relationships of one's hands to tools and one's intellect to mathematics. One can do a great deal of work with one's hands, and one of the things that one's hands can do is build tools with which to do even more work. So also one's intellect can accomplish much in its own right, and one of the things that the intellect can do is "build" mathematics, a "tool" with which one can accomplish even more. Skemp concludes the thought with these words: "If this view is correct, then it is predictable that children will not succeed in learning maths unless they are taught in ways that enable them to bring their intelligence, rather than rote learning, into use for the learning of mathematics" (p. 7). And in bringing their intellect to bear on their learning of mathematics, students will be constructing that particular knowledge that we call mathematics.

*Knowledge is Organized in Networks*

Skemp would call these networks "schemas," in the style of the psychology that helps to shape his perspective. Nevertheless, he finds the construction of schemas crucial in the learning of mathematics.

Davis (1984) would use the term "frames" to describe a similar construct. He sees children who understand mathematics as having developed a large number of ideas that are connected in networks that provide a context for meaning. These frames may then serve as a foundation for future learning.

Regardless of the precise terminology used, conceptual knowledge grows through the construction of relationships among individual bits of information. The heart of this process is what Piaget called adaptation. That is to say, new knowledge is assimilated into a network of existing knowledge structures, and changes in those knowledge structures are made to accommodate the new knowledge (Piaget, 1983).
In describing the relationship between conceptual and procedural knowledge, Carpenter (1986) has written that "it is an iterative process; procedures are taught that can be supported by existing conceptual knowledge, and the conceptual knowledge base is extended to provide a basis for developing more advanced concepts" (p. 130). This is, in a sense, Piaget's notion of cognitive adaptation at work again. Through the dual processes of assimilation and accommodation, these networks become increasingly more complex and abstract. In fact, Cobb (1988) believes that "a fundamental goal of mathematics instruction is or should be to help students build structures that are more complex, powerful, and abstract" than the ones that they already possess (p. 89).

Resnick (1987) has found a substantial research base to support the contention that children's difficulties in learning school mathematics are closely related to their failure to connect the formal mathematics taught in school with their intuitive mathematical understandings. Schoenfeld (1988) argues that students often fail to connect the meanings of the formal symbols that they use with the real-world objects being represented.

Skemp (1987) worries that rote, or what he calls instrumental, learning will actually block later conceptual, or relational, learning. He believes that this could occur due to a failure to develop conceptual schemas upon which to base later learning.

No matter the precise terminology used, Shulman (1992) succinctly captures this line of reason thusly: "the manner in which prior understandings serve to frame, organize, and scaffold future learning is undeniable. The message of a constructivist social science is consistent and clear" (p. 25).
Knowledge is Continuously Reorganized and Restructured

The individual is in a constant condition of assimilating new information, and from a constructivist perspective, this continuous assimilation must be accompanied by resulting accommodation, or changes in the organization and structure of existing knowledge. Such a model of learning is clearly based to a large extent on experience (Cobb, 1988; Noddings, 1990; Skemp, 1987; Underhill, 1991; von Glasersfeld, 1990). The constructivist might, in fact, view knowledge itself as the result of a struggle to make sense of experience on a conceptual level. Speaking of the experiential world in which we live, von Glasersfeld argues, "this world is not an unchanging independent structure, but the result of distinctions that generate a physical and a social environment to which, in turn, we adapt as best we can" (p. 23). As that experience adds to the individual's knowledge base, reorganization and restructuring are inevitable. The trick is to provide learners with purposeful experiences that will lead to reflective activity on their part. In this way, their knowledge base can be extended. Unfortunately, as Carpenter (1986) has observed, this is no easy task.

Construction of Knowledge is a Reflective Activity

Cobb (1988, 1989) believes that mathematical structures are constructed by reflection on and abstraction from sensorimotor and conceptual activity. Beyond one's individual constructions of knowledge, however, Cobb sees an anthropological perspective that gives rise to what he terms "institutionalized knowledge" (1989, p. 33). From this vantage point, "analyses that focus solely on individual children's construction of knowledge tell only half of a good story" (p. 34). In Prawat's (1993) interpretation of this approach, there is "a dialectical relationship between individual knowledge, arrived at by reflecting on one's own activity, and knowledge that is socially mediated and jointly agreed on" (p. 11). Exacerbating this tension, in Cobb's
view, is the inevitable effect of acculturation and institutionalization on the form of the individual's reflective activity.

Von Glasersfeld (1983) calls mathematical knowledge the product of reflection. However, he believes that students have no reason to build new conceptual structures unless their current knowledge and level of understanding lead to some sort of problematic conflict. Confrey (1991) describes the process of reflective abstraction in these terms:

We act through sensory-motor and cognitive operations. We use tools and previously familiar systems of representation. Then we monitor the results of our actions to see if the problematic has been resolved and equilibration restored. This may end the sequence, lead to a reconsideration and perhaps alteration of the problematic, and subsequently a new cycle of action and reflection. (p. 118)

I believe it is important that Confrey, in describing such a Piagetian construct as reflective abstraction, ascribes a prominent role to the "tools and symbols" which so interested Vygotsky (Kozulin, 1990, pp. 110-150). This suggests a sociocultural, as well as a cognitive grounding for constructivist thinking in mathematics education.

Just as does Confrey, Underhill (1991) also sees cycles in the process of constructive learning. His account posits cognitive conflict coupled with curiosity as the primary motivational device in the learning process. He sees peer interaction as a means of fostering cognitive conflict, cognitive conflict as a catalyst to individual reflection, and reflective activity as inducing a cognitive restructuring. Finally, since the process must occur within the individual's experiential field, any cognitive restructuring must eventually be followed by further peer interactions, whence a new cycle begins. Figure 1 provides a simple model of my interpretation of Underhill's description of the cycle.
Figure 1: A Cyclic Model of the Construction of Knowledge

Perhaps the most powerful aspect of Underhill's thinking is that it yields a form of empowerment. The learning cycle just described empowers learners, because they are now perceived as being "in control of their own learning" (p. 230).

Constructivists seem to be in general agreement that reflection plays a critical role in the construction of knowledge. The more abstract the concept that awaits construction, the greater is the need for such reflective activity, thereby allowing the learner to make sense of the abstraction (von Glasersfeld, 1983).

These ideas regarding the construction of knowledge by learners are consistent with Kolb's conception of learning as a four-stage cycle (1981). He posits the need for learners to develop abilities in four areas: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Moreover, Kolb believes that such a model of learning implies the necessity of intellectual abilities that are dialectically opposed. Thus he sees the juxtaposition of concrete experience with abstract conceptualization and reflective observation with active experimenting producing two dimensions of learning. Kolb describes his model in these terms:
Immediate concrete experience is the basis for observation and reflection. An individual uses these observations to build an idea, generalization, or "theory" from which new implications for action can be deduced. These implications or hypotheses then serve as guides in acting to create new experiences. (1981, p. 235)

An Extension of the Model

Many researchers believe that successful educational reforms demand an understanding of the processes by which teachers change (Hart, 1993; Richardson, 1990; Schifter, 1993; Shaw & Jakubowski, 1991; Wood, Cobb, & Yackel, 1991). Often, an understanding of complex processes can be enhanced through the development of a model. Indeed, with respect to the construction of a model for teacher change, Goldsmith and Schifter (1993) note that "the means by which teachers develop their practice are as yet little understood; it is critical that we develop some models for the growth of teaching practice if we are to succeed in stimulating such change on a wide scale" (p. 124). To that task we shall now direct our attention.

Hart (1993) believes that practicing teachers who are attempting to make changes that reflect some of the recommendations generated by the current reform effort in mathematics education face "a difficult and complicated struggle" (p. 189). She also believes that learning is a process of providing structure and organization to one's world in order to make sense of experience (Hart, 1991). Moreover, she believes that learning occurs as knowledge is modified in dealing with problematic situations. Thus, it is an easy extension for her to suggest that teachers, in attempting to change, will modify their knowledge and beliefs about teaching and learning if their attempts are made problematic.
Cooney (1993) acknowledges that the teaching of mathematics is, by its very nature, a problematic activity. Furthermore, he suggests a fundamental role for reflectivity in the process of teacher change. In his view, "the notion of reflection is rooted in the constructivist notion of adaptation; the relevance of reflection and adaptation ... is that neither can meaningfully take place from a closed, dualistic perspective" (p. 45).

Shaw, Davis, and McCarty (1991) likewise ground their theoretical framework of how teachers change in constructivism, but carry the theory a step further with their notion of teacher change precipitated by perturbation, or mental dissonance. They argue that those who are interested in effecting change in teachers' practice should expose teachers to alternatives in theories of learning and teaching as well as classroom activities. Such exposure is believed to cause perturbation, followed by frustration and discomfort, followed by the reflection that leads to change. Shaw and Jakubowski (1991) also note the importance of peer support and collaboration in the process of teacher change. Thus, the same, or similar features from the model of the construction of knowledge developed in Figure 1 on p. 12 can be seen as descriptors of the teacher change process.

In Figure 2, the simple constructivist model of learning in Figure 1 has been easily modified to a model for teacher change. The peer interactions could take several forms (discussions with colleagues, discussions with administrators or researchers, exposure to new ideas), but the key steps would seem to be the manufacture of some form of perturbation which, in turn, elicits reflective activity in the teacher. Thus, a framework has been built for studying teacher change by extending some of the major tenets of a constructivist view of learning to a perspective which views teachers as learners.
Figure 2: A Cyclic Model of Teacher Change

Earlier in this discussion it was suggested that teachers are reflective thinkers who use a problem-solving approach to instructional decision-making. Note that the key role of perturbation in this model is compatible with the view of teaching as a problem-solving activity. At the same time, the pivotal role of reflection in the model also assumes that teachers are reflective thinkers.
CHAPTER III

THE RELATED LITERATURE

"Man is an animal suspended in webs of significance he himself has spun."

- Clifford Geertz (1973, p. 5)

A review of the literature on teacher change clearly suggests that change is based on many factors, but several come to the foreground in a number of studies. Some pervasive themes seem to be teachers' inclinations to change, their reflective thoughts regarding their own practices, the degree to which they experience collegiality and peer interaction in their work environments, and the time they can devote to aspects of change.

Pervasive Themes

In analyzing the process of innovation in education through what he calls "reflection-in-action," Schön (1983) identifies three key aspects of change: time, inclination, and systematic reflection. He further views the prospects for reflective teaching somewhat pessimistically, identifying teacher isolation as a major constraint to the development of a reflective practice. Schön argues that supervisory support of a teacher's efforts to develop such a practice and opportunities for the teacher to collaborate with peers are necessary conditions for the emergence of a reflective practice.

Teacher collegiality has long been seen as one avenue to change in teaching practice (Lortie, 1975). From this perspective, exposure to peers who perform the
same job differently, but well, is conducive to an atmosphere which may foster a
disposition that is favorable to change. Lortie notes the importance of such a
favorable disposition to change with the observation:

Many proposals for change strike them [teachers] as frivolous - they do not
address issues of boundedness, psychic rewards, time scheduling, student
disruption, interpersonal support, and so forth. People interested in change
should take such beliefs and preferences very seriously, for they reflect first
hand experience. (1975, p. 235)

Fullan (1982, 1991) has studied the change process in schools over the course
of a decade or more. He identifies three dimensions of change that follow the
implementation of educational innovations:

• the use of new or revised materials,
• the use of new teaching approaches, and
• the alteration of teachers' beliefs.

Fullan believes that all three of these dimensions are necessary for successful change
initiatives, as "they represent the means of achieving a particular educational goal"
(1982, p. 30). Confounding the process of teacher change, however, is Fullan's
observation that individual teachers might demonstrate change in zero, one, two, or
all three dimensions.

Fullan also acknowledges the essential role of peer interaction and support, as
well as teachers' reflective activity in the process of successful change. Furthermore,
he hypothesizes that the more teachers experience the rewards of peer interaction, the
more likely they will be to seek such interaction for the purpose of professional
development. There is a clear need, in Fullan's view, for increased time in teachers'
workdays for meeting, planning, and otherwise interacting professionally with each
other.
Finally, Fullan suggests that significant change always involves a certain amount of ambiguity, ambivalence, and uncertainty and that the meaning of the innovation must be worked out by the individual implementers themselves. Consequently, "conflict and disagreement are not only inevitable but fundamental to successful change" (Fullan, 1982, p. 91).

Doyle & Ponder (1977) believe that three distinct images of teachers with regard to educational innovation emerge from the literature concerning teacher change:

- the rational adopter,
- the obstructionist, and
- the pragmatic skeptic.

In arguing for the primacy of the image of a pragmatic skeptic over that of a rational adopter, Doyle and Ponder note the tendency of teachers to adapt innovative practices during their adoption.

In their view, the culture of the teaching profession in contemporary America places teachers in a position of relative isolation and autonomous decision-making. Such an environment is disrupted during any change initiative. Doyle and Ponder believe that teachers, in deciding to what extent to implement a specific change in practice, take an ecological perspective. From this vantage point, the decision to implement a given change has much to do with the perceived fit between the innovation and the environmental demands of the implementer's particular situation. Thus, those who desire the successful implementation of educational innovation are cautioned to take into account the degree of disruption to teachers' normal routines that the innovation engenders. Indeed, "failure to acknowledge ecological effects -
the interaction of environment and teacher behavior - apparently can have significant long-range implications for change strategies" (Doyle & Ponder, 1977, p. 6).

In studying the organizational features of schools as they relate to a teacher's level of commitment and willingness to learn, Rosenholtz, Bassler, and Hoover-Dempsey (1986) find that principal collegiality, teacher collaboration, and shared decision-making contribute significantly and substantively in explaining the variance in teachers' skill acquisition. Principal collegiality, or the perception by the teacher of the principal as a partner in professional activity, is believed to directly influence the likelihood that teachers will take their principal's "suggestions and encouragement for professional development seriously" (Rosenholtz, Bassler, and Hoover-Dempsey, 1986, p. 99). Teacher collaboration, or the ease with which teachers engage in professional interaction with each other, is believed to directly affect skill acquisition. These researchers suggest that collaborative effort both supports teachers and provides them with incentives for acquiring skills. When principal collegiality and teacher collaboration are combined with teacher involvement in educational decision-making, Rosenholtz, Bassler, and Hoover-Dempsey hypothesize that teachers feel competent and valued. Certainly, teachers with such feelings may well be more disposed to view change in a sense of professional development and in a favorable light.

Sarason (1971, 1990) has repeatedly argued over the course of two decades for the efficacy of including teachers in any decision-making relative to change initiatives. He sees a clear need to involve the implementers of change, that is teachers, in the change process because "when a process makes people feel that they have a voice in matters that affect them, they will have a greater commitment to the overall enterprise and will take a greater responsibility for what happens to the
enterprise" (1990, p. 61). The exhibition of commitment to and responsibility for change notwithstanding, Sarason is also keenly aware of time constraints in teachers' workdays. He notes that "any conception of the change process in regard to schools explicitly or implicitly involves a time perspective" (1971, p. 219).

Shulman (1986) finds reflection the key process in a teacher's progression from skilled technician to professional. He believes that "the professional holds knowledge, not only of how, but of what and why" (p.13), and it is the reflective process that allows the teacher to achieve the sort of metacognitive awareness that leads to the capacity "not only of practicing and understanding his or her craft, but of communicating the reasons for professional decisions and actions to others [italics added]" (p.13). Moreover, Shulman argues persuasively for the development of a case knowledge in education. He sees the establishment of a case method similar to that employed in the study of law as a valuable means of studying educational theory.

Reflection was also seen to be an important factor in promoting teacher change in a study seeking to learn why teachers do not use the current research on reading (Richardson, 1990). In one aspect of the study, the change process was investigated in some depth through a staff development program working with teachers of Grades 4, 5, and 6 in four schools.

Teachers in this program were exposed to the current research base and their practical knowledge was elicited during individual and group sessions. In addition, there were follow-up activities during the school year, which included classroom modeling, observations, opportunity to observe colleagues, and articles for reading.

Richardson found that the teachers in her study changed almost continuously and could often justify doing so. The melding of a research-based practice with the teachers' practical knowledge base and belief structure apparently altered their
practice dramatically. Richardson believes that the key aspects were the teachers' empowerment in the process of change and the reflective activity that made that empowerment possible.

Thus, it is clear that teacher's inclinations, including predisposition and commitment, their reflective activity, their opportunities for professional interaction, especially with peers, and the time that they have available in their workday to devote to aspects of innovation are closely related to their success in making worthwhile changes in practice. In the absence of these four factors, teachers are not likely to alter their normal routines of practice in any substantive way.
Toward a Constructivist Model

The peer interactions and teacher reflectivity noted in the previous section fit directly into the cyclic model for teacher change that was proposed in the previous chapter. Tobin (1987), on the basis of several studies of the implementation of mathematics programs in schools, concludes that teachers teach what they teach in the ways that they do in the belief that what they are doing is best for their students. This suggests two possibilities. First, if teachers are to be led to change their practice, they must first be convinced of the need for such change. This brings to mind the idea of making that practice, or aspects of it, in some way problematic. Secondly, once teachers do view a need for change in their practice as being in the best interests of their students, they are more likely to make a commitment to implement such changes. For this process to reach fruition, in addition to such commitment, sufficient time and support are needed to effectively bring innovation into teachers' daily routines, that is to make innovation routine.

The notion of making aspects of practice problematic to serve as a catalyst for change is by no means a recent one. March and Simon (1958) attribute persistence of behavior to the absence of any search for alternatives whenever the existing program is judged satisfactory. They further conjecture that an individual's experiential knowledge might strongly influence that person's disposition towards change within an organization.

Thus, the research reviewed thus far suggests grounding the conceptualization of teacher change as a cyclic process of self-construction. One might hypothesize that through a process of interaction, often with peers, some aspect of a teacher's
practice is made problematic for the teacher. This is followed by reflective activity, which may or may not lead to some form of change in practice. If change indeed occurs, further interactions, with students or again with peers, begins a new cycle.
Constraints to Change

Those interested in studying teacher change need to be aware of some substantive constraints to such change. Wirt and Kirst (1989) note that their research suggests that mandated change in the absence of any feeling of teacher ownership is often counterproductive. Fullan (1982) believes that "the lack of opportunity for teachers to reflect, interact with each other, share, learn, develop on the job makes it unlikely that significant changes will occur" (p. 118).

Duffy and Roehler (1986), in analyzing four years of their research, concluded that several factors constrained their project teachers' dispositions to change. Teachers in their studies were seen to have persistent difficulty effecting change in their instructional practices within the limits of their respective curricula. This appeared particularly problematic when the innovation sought conflicted with their prior experience. Some of the teachers in these studies found it especially difficult to deal with the possibility that there might be a better way of doing something that they had been doing for many years, and in their view, doing successfully.

Some of the constraints that these researchers identified were clearly organizationally based. For example, there was often district-level pressure in the opposite direction from the changes sought. Other such constraints were of a more local nature, having to do with disruptions to daily routines and the like.

While one hardly doubts that the teachers in these studies were in fact constrained by these and other factors, one also notes that these teachers had no part in the development of the innovation, and hence felt no ownership of it. Moreover, there seems not to have been consistent, district-level support for these teachers'
efforts to change. Finally, and perhaps most troublesome, there was an apparent lack of meaningful peer interaction among these teachers on any regular basis.
Ownership and Making a Difference

In contrast to the constraints to change noted in the previous section, teacher ownership and reflective analysis of an innovation project in the Philadelphia schools were considered crucial to the success of the project (Stetzer, 1991). From the beginning, the Philadelphia teachers themselves determined the form and content of their project. Additionally, their thorough and thoughtful review of the curriculum materials and instructional practices used helped to shape their inservice support to fit their own needs. Unfortunately, Stetzer's report is merely descriptive and contains no data relevant to teacher change.

Rudduck (1988) also sees ownership of change crucial to successful teacher change initiatives. In studying three science teachers in a curriculum development project in the United Kingdom, she theorized that changes in teachers' professional attitudes are more likely to occur when the teachers themselves have constructed a rationale for such changes. Her model is also based on the assumption that teachers can be stimulated to reflective analysis of their practice through problematic situations.

McLaughlin and Yee (1988) saw the quality of a teacher's experiences within the framework of change as the most critical determinant of whether the individual actually made substantive and long-term changes. In their view, "the strongest incentives for teachers derive their power from enabling teachers to reap psychic, intangible benefits from making a difference in the classroom" (p. 25).
Constructivist Models of Teacher Change

In a study of changes in elementary teachers' instructional practices in mathematics, Carpenter, Fennema, Peterson, Chiang, and Loef (1989) take a cognitive view of the teacher. From this perspective, teachers are seen as rational decision-makers who approach teaching as a problem-solving activity. The purpose of this study was to investigate whether providing teachers with specific knowledge from the research base concerning children's thinking in specific content areas would influence the teachers' practices and their students' achievement.

The study was conducted with 40 first-grade teachers, half of whom were randomly assigned to the treatment group, the remaining half serving as the control. The treatment group participated in a four-week summer workshop, the focus of which was to help teachers to understand and interpret explicit research findings on how young children learn and develop addition and subtraction facts. On the other hand, the control group participated in two 2-hour workshops whose focus was nonroutine problem solving.

Although no instructional practices were prescribed for either group, the researchers found that the teachers in the experimental group taught problem solving significantly more, and number facts significantly less, than did the teachers in the control group. In addition, the experimental group tended to encourage a variety of problem solving strategies and listened to their students' thinking significantly more than the control group. Students in the experimental classes were also found to exceed those in the control classes in both number fact knowledge and problem solving.
Carpenter and others believe that the results of this study clearly suggest that one means to effect change in teaching practice is to expose teachers to specific research results in rather narrow areas, while helping them to understand and interpret the research. In this manner, teachers apparently become better able to make informed choices regarding instructional practices.

While this study used questionnaire data to assess teachers' beliefs and classroom observations to look for evidence of teachers' change in practice, teacher interviews did not address the teachers' thought processes. Thus, this study provides no information about what the teachers' thoughts about the changes in their own practice might have been. Again, one expects that the results here would generalize, but this study was limited to a small subset of mathematics instruction at only one grade level.

In a case study of one second-grade teacher in an innovative mathematics teaching improvement project, Wood, Cobb, and Yackel (1991) report changes in that teacher's instructional practices in mathematics. They describe a process of change that is compatible with a constructivist model for teacher change. This teacher changed as she reorganized her practice to resolve conflicts and dilemmas that developed between her former norms of practice and the constructivist emphasis of the innovation project. What is perhaps most interesting about this study is that, as a consequence of the researchers' view of teaching as a problem solving activity in which teachers exercise their professional judgment, the project teacher was not provided with any detailed recipes or prescriptions for practice. Thus, this teacher was left to make her own decisions based on her own knowledge and experience as she applied these to problematic situations that she encountered.
Wood and others found that project meetings provided the teacher with the opportunity for reflective activity regarding her practice. This led her not only to make changes in her practice, but to reconceptualize her role as a teacher as well. They also note that "change did not occur as single incidents, but instead as gradual constructions and transformations" (p. 597).

Wood and others conclude from their investigations that those interested in effecting change in teachers' instructional practices need to provide opportunities for teachers to learn in the setting of their own classrooms. Moreover, teachers need to interact with peers who are involved in the same process.

In an attempt to understand why teachers do what they do, Tobin and Jakubowski (1992) make five assertions:

- Teachers believe that they must play some specific roles. Among these are that of facilitator of learning, manager, assessor, and curriculum designer.

- Teachers beliefs regarding these roles, as well as their conceptualizations of these roles, are influenced by their personal theorizing.

- Teachers use visual and verbal metaphors in order to understand their roles.

- It appears that changes in teachers' conceptualizations of their roles, the metaphors they use to understand those roles, and their associated beliefs about those roles precede any changes in teachers' classroom practices.

- The metaphors and beliefs that teachers use to guide their actions seem to depend upon context.
Based upon these assertions, Tobin and Jakubowski theorize that teacher change depends upon three main points: a commitment to the need for change, the construction of a personal vision of change, and reflections on thoughts and actions.

In a similar vein, Shaw and Jakubowski (1991) believe that their research supports the existence of six factors in the process of teacher change. They believe that in order for substantive changes to occur, teachers must:

- experience a perturbation,
- have a commitment to change,
- construct a vision of what specific changes might look like within their own classroom,
- project themselves into that vision,
- decide to make changes within a given context, and
- be reflective practitioners.

Shaw and Jakubowski see perturbation as a necessary condition to change in practice, because in its absence, individuals are likely to be satisfied with their current practice of teaching. A perturbation is needed to upset the equilibrium. However, perturbation or not, change is unlikely without commitment. This is the force that sets the change process in motion.

Nevertheless, Shaw and Jakubowski believe that perturbation and commitment alone are insufficient to elicit change, and that teachers must construct a vision of what their changed practice might look like. This requires viable alternatives. Moreover, peer collaboration and support often aid in the construction of such visions.

Having constructed a vision of a changed practice, it is then necessary to project oneself into that vision. Shaw and Jakubowski believe that those unable to do
so are unlikely to change. Those who are capable of such a projection then often decide to change within a given context. Finally, a reflective practice is necessary so as to compare one's actual practice with one's vision. In fact, in this model, it is teachers' reflections on their practice that is seen as the force that drives the entire process.

Again, these factors are consistent with the model for teacher change that was developed earlier. However, they also seem to suggest ways in which the four processes of that cyclic model - peer interaction, perturbation, reflection, and actual change - might be externally driven. One is led to conjecture that the entire change process may well occur within a personal atmosphere that is charged with a commitment to change. Furthermore, the construction of a vision is clearly the result of reflective activity and quite possibly an interactive process. That is to say, reflective activity leads to the construction of a vision, which leads to more reflective activity, which leads to refinements of the vision, which leads to further reflective activity, and so on.

Simon and Schifter (1991) also have found evidence that teacher change is related to the development of "a vision of mathematics learning and teaching consistent with recent reform movements" (p. 328). They found follow-up support of teacher's efforts to effect changes in their own practices to be a critical factor. Moreover, they cite teachers' development of their own theories of learning as the single most important aspect impacting on changes in teaching practice. Clearly, the development of a personal theory of learning is the result of a reflective practice.

This review of literature has attempted to identify some features of educational innovation that appear to be associated with success in fostering teacher change. Mostly, these features deal more with how the innovation is organized and
supported, and less with the protocols of the particular innovation itself. Inasmuch as
the bulk of the literature on teacher change deals with elementary and, to some extent,
middle school teachers, it would be interesting to examine the change process in
secondary mathematics teachers.

Nelson (1993) asks what the role of "new and supportive curricula" (p. 24)
might be in helping teachers to observe student thinking. To this should be added the
question of whether innovative curriculum materials play a more general role in the
process of teacher change.

Of particular interest is the question of whether a "Standards-like" curriculum
project such as the UCSMP secondary component can in itself be an agent for change
when implemented in a manner consistent with those features that have been
identified as critical to successful change initiatives.

A Revised Model

At this point in this researcher's conceptualization of the process of teacher change, a somewhat more detailed model than the one presented earlier seems
appropriate. Figure 3 shows the incorporation of peripheral factors into the cyclic,
constructivist model of Figure 2 on p. 15. In the revised model, innovative
curriculum materials are seen as a possible source of perturbation for teachers. At the
same time, inservice meetings, particularly ones having a direct relationship to the
innovation, possibly provide a context within which teachers might interact with
peers, and the process of keeping a journal is viewed in a joint catalytic relationship
with reflection. That is to say, the keeping of a journal can seed reflective activity,
while reflective activity provides the content of the journal. Finally, from the
perspective of the model, the construction of a vision of change, seen by Shaw and
Figure 3: Peripheral Factors in the Cyclic Process of Teacher Change

Jakubowski (1991) as a cognitive requisite to change in practice, occurs as a result of reflection. Once again, an interactive connection between reflection and the vision is posited, because a vision is seen as the result of reflection and as a catalyst to further reflection.
CHAPTER IV

RESEARCH DESIGN AND METHODOLOGY

"Until we turn our thoughts from measurement to function, the most important questions about intelligence will remain not only unanswered, but barely even asked."

- Richard Skemp (1987, p. 6)

Several research questions were proposed in Chapter I. These dealt not only with the question of whether teachers change their practices during the implementation of curriculum innovations, but with how and why such change might occur as well. Clearly, the latter two are the more interesting questions at hand. Rist (1983) suggests that "qualitative research is appropriate to the articulation of the multiple ways in which people understand their world and react to it" (p. 16). For this reason, a qualitative methodology using case study techniques was used in this study.

Toward a Research Methodology

Goetz and LeCompte (1984) have described ethnographic, or qualitative, research as attempting "to describe systematically the characteristics of variables and phenomena, to generate and refine conceptual categories, [and] to discover and validate associations among phenomena" (p. 8). After tracing a history of the tensions between quantitative, experimental research and more qualitative methods, such as case studies, Stake (1978) notes that any perceived disadvantage of the case study method disappears "when the aims are understanding, extension of experience, and increase in conviction in that which is known" (p. 6). Moreover, Rist (1983)
contends that "to understand any social program or social setting, one must describe and analyze in an ecologically valid manner the values, behaviors, settings, and interactions of the participants" (p. 13).

Bogdan and Biklen (1982) identify a number of commonalties of sound qualitative research. In such a methodology, the natural setting is the direct source of data, and the researcher is the key instrument of data collection. Qualitative research tends to be descriptive and shows more concern with process than product. Data are analyzed inductively so as to draw meaning from them, and it is this meaning that is of primary interest.

Whether the intent of the research is to generate new theory or to extend or validate existing theory, qualitative research demands a theoretical framework in either case (Bogdan & Biklen, 1982; Goetz & LeCompte, 1984; Strauss, 1987). A theoretical framework for qualitative studies that also underpins the constructivist accounts of learning and the process of teacher change that were developed in Chapter II is described by Blumer (1969) as "symbolic interactionism." Blumer, in developing this perspective, acknowledges the contributions of John Dewey and George H. Mead to his thinking.

Symbolic interactionism may be considered a form of phenomenology based on the premise that human experience is mediated by interpretation (Bogdan & Biklen, 1982). In Blumer's (1969) account, human action is based on meanings. All meanings are believed to arise from social interaction, and the creation of meaning through such interaction is seen as an interpretive process.

Patton (1990) notes that symbolic interactionism is closely associated with the verstehen orientation. Verstehen is the German word for understanding. This tradition places emphasis on the human capacity to know and understand others through
empathic introspection and reflection based on direct observation of and interaction with people" (p. 57). This entire interactive process thus hinges on one's ability to interpret the symbols with which another signals meaning and understanding.

These ideas dovetail nicely with a constructivist perspective in which the process of coming to know occurs not through sensory perception directly, but through physical and mental actions on one's environment. But there is also a socio-cultural function that must come into play, for "construction of knowledge therefore is, on the one hand, a result of very general [endogenous] processes, ... and, on the other hand, of the way objects are presented to the subjects with their societal meanings" (Sinclair, 1990, p. 23).

Noddings (1990) finds most constructivist methods of eliciting student thinking in whole class situations "highly interactive" (p. 17), while Goldin (1990) notes that, in the constructivist account, "social conventions and social interactions in contexts ... often function as the most important determinants of whether an individual's knowledge is regarded as valid" (p. 35).

Confrey (1990) sees constructivism as a theory that seeks to explain the limits of human knowledge by considering knowledge and understanding to be products of human experience. "Decentering, the ability to see a situation as perceived by another human being, is attempted with the assumption that the constructions of others ... have integrity and sensibility within another's framework" (p. 108). This implies that, from a constructivist perspective, it is legitimate to seek to understand the symbols through which another individual constructs knowledge, as well as the other's means of signaling understanding. This is precisely the position taken by symbolic interactionism.
The methodological stance of symbolic interactionism is direct examination of the empirical social world, which Blumer (1969) defines as "the world of everyday experience" (p. 35). Continuing with Blumer's account of the methodological position supported by symbolic interactionism, the only way to assure that one's premises, problems, data, relations, concepts, and interpretations are empirically valid is to go directly to the empirical social world - to see through meticulous examination of it whether one's premises or root images of it, one's questions and problems posed for it, the data one chooses out of it, the concepts through which one sees and analyzes it, and the interpretations one applies to it are actually borne out. (p. 32)

It is little wonder that Bogdan and Biklen (1982) were led to observe that symbolic interactionism relies heavily on participant observation.

In Rist's view, "qualitative research is well suited to the study of the implementation process" (1983, p. 23). He notes that in any study of social change, unanticipated events occur. It is to the study of such unanticipated events that Rist finds the application of qualitative methods particularly applicable.

Ernest (1989), in considering the all too frequent divergence between what teachers say or believe that they do and their actual practices, argues for the direct observation of those teaching practices. He notes that "case studies have shown that there can be a great disparity between a teacher's espoused models of teaching and learning, and the models actually realised in the teaching of mathematics" (pp. 25-26), citing Brown (1986), Cooney (1985), Cooney and Brown (1986), and Thompson (1984).

Shulman (1986) argues persuasively for the efficacy of a case knowledge in the study of teaching. He envisions the study of a case literature in teacher education providing a much needed link between theory and practice. His argument ought to be
extended to the development of a case literature in order to facilitate an understanding of the process of change in teachers' practice.

Strauss (1987) presents a rubric for the construction of case studies that begins with the collection of data. The data are then analyzed and a theory is built around a particular phenomenon of interest. This is followed by the construction of a working model of the case study that pays close attention to the theory. When done well, all of the theoretical elements of the case study and the relationships among them will be carefully and thoughtfully described. Finally, illustrative data can be built into the case study so as to enhance understanding, credence, comprehensibility, and reality.

To this model, Bogdan and Biklen (1982) add the caveat to actively seek cases that do not seem to fit the theory as currently formulated. They believe that only by modifying the definition and explanation of the phenomenon as cases are encountered which do not fit the present model can a universal relationship finally be established.

For this reason, the sampling techniques used in qualitative research are frequently purposeful rather than random. In some instances, the researcher might choose to sample units of analysis that are fairly representative of some larger population. In other cases, the researcher might choose to follow the suggestion of Bogdan and Biklen by sampling units of analysis that are somewhat atypical.

Objectivity in a qualitative design is a matter of establishing both validity and reliability, just as it is in a quantitative methodology. Schön (1991) suggests that qualitative researchers derive objectivity from the ethnographic method; that is, "the careful qualitative description and analysis of case studies drawn from actual observation of an individual's or a group's practice" (p. 344). This idea maps nicely onto Kirk and Miller's (1986) suggestion that the one of the strengths of qualitative
methodologies is that their validity is grounded in field observation and that their reliability originates in the researcher's documented ethnographic decision-making.
Design of the Pilot Study

"Diane" is a teacher in the UCSMP implementation project described in Chapter I. She began teaching with the UCSMP materials for the first time during the 1992-93 school year. In the spring of 1992, a subset (n=31) of the UCSMP implementation teachers who would begin teaching with UCSMP materials in the fall was selected to complete a teacher beliefs and attitudes survey. (See Appendix A for the survey protocols.) Diane was selected for case study on the basis of the results of that survey, as her responses to the survey indicated that she was fairly typical of the group who completed the survey. (See Appendix D for details.)

Beginning in mid-September 1992, Diane's teaching load consisted of the two 8th-grade classes in which the UCSMP Transition Mathematics curriculum was implemented and three 7th-grade mathematics classes that did not use the UCSMP materials. It should be noted that this district has chosen to implement the Transition Mathematics curriculum at the 8th-grade level, although it was written for the upper 85% of American 7th-grade students.

In addition to her regular load, during a 45-minute period daily before the start of the normal school day, Diane taught three 8th-grade students the district's standard 9th-grade mathematics curriculum - an integrated course in beginning algebra, informal geometry, symbolic logic, probability, and data analysis. She did this on a voluntary basis.

To collect data on Diane's practice, the researcher visited Diane's school six times during the 1992-93 school year. These visits were in October, November, January, February, March, and April. Each of Diane's UCSMP classes, and her first
period, non-UCSMP Mathematics 7 class were observed during each visit. The researcher kept field notes of those observations.

Each time the researcher visited, Diane was interviewed at the end of the school day or during her preparation period. These interviews typically lasted 30-45 minutes and were audiotaped. They were conducted using an interview guide as suggested by Patton (1990). The six interview guides appear in Appendix E.

Diane also kept a weekly journal of reflections on her work. Because the researcher was not able to visit in December, one day early in the month Diane videotaped the same three classes that the researcher ordinarily observed. The researcher added notes regarding this videotape to his regular field notes of observations.

Qualitative researchers frequently attempt to strengthen the design of their studies through the use of triangulation. Romberg (1992) makes the point that failure to triangulate evidence when building an argument in a case study is a common error that calls into question the quality of the research effort. By collecting data from three primary sources: classroom observations, interviews, and a participant's journal, the researcher sought to avoid this fatal flaw. Insofar as practical, Patton has proposed triangulation in four dimensions: data-collection methods, data sources, investigator or analyst, and theory. As previously noted, an attempt was made to triangulate the data in this study. This was done in terms of both methods of data collection and sources of data within a given method. Because the study was intended to be a dissertation pilot, investigator/analyst triangulation was not possible.
Design of the Main Study

The selection for study during the 1993-94 school year of two teachers new to the UCSMP implementation in this district was somewhat problematic, because the district-wide implementation occurred in 1992-93. Thus, most of the teachers in this district who taught with UCSMP materials during 1993-94 were not doing so for the first time. This factor severely limited the pool of potential teachers for study in 1993-94.

With the help of the Director of Mathematics, the researcher was able to identify two teachers, "Gina" and "Kathy", who would be using UCSMP materials for the first time in 1993-94. They both agreed to be part of the study. In April 1993, each of them completed the same beliefs and attitudes survey referenced earlier. (See Appendices B & C for Gina's and Kathy's responses.) While Kathy's responses were fairly typical of the original group's responses, as were Diane's, Gina's responses were much more atypical.

Gina teaches 7th-grade mathematics in a large grade K-8 school of over 1,000 students. Many of her students speak English as a second language (ESL students). She implemented 7 of the 13 chapters in the Transition Mathematics textbook in her classes during 1993-94. It was thought that Gina's implementation would be particularly interesting to follow, given the importance of student reading of the textbook in the UCSMP approach juxtaposed with the large number of ESL students with whom she would be working.

Kathy teaches mathematics in a grade 9-12 high school. She taught the UCSMP Algebra course to three of her classes during 1993-94. These classes were all
mixed grade levels, 9-12. As most of the research on teacher change has studied teachers in grades K-8, and the majority of that in grades K-6, to follow Kathy's implementation in a secondary school setting seemed particularly interesting.

To collect data on Gina's and Kathy's practices during 1993-94, the researcher visited each in her school a total of eight times between September 1993 and April 1994. These visits were spaced at three- to five-week intervals. During each of these visits, two each of Kathy's and of Gina's UCSMP classes were observed. The researcher was also able to observe Gina in April 1993 in a attempt to establish a baseline.

The researcher found the semi-structured interview technique using an interview guide to be satisfactory during the pilot study. Therefore, the same procedure was followed in the main study. A strength of this methodology seems to be that the construction of an interview guide prior to each visit forces the researcher to periodically review and interpret the data that have previously been collected.

In the pilot study, the researcher found Diane's weekly journal to be a particularly rich source of information. Therefore, participants in the main study were also asked to keep a weekly journal. One weakness of the pilot study was the researcher's inability to convey to Diane the true import of her journal to his analysis. While most of what Diane wrote in her journal showed a fair amount of reflection, and while much of the information that she provided via her journal was invaluable to the researcher, several times during the study, Diane went two or three weeks without making any journal entries.

In the main study, the researcher stressed to Gina and Kathy the importance of making regular weekly journal entries. He also made frequent references early in the study to the participants' journal writing and its importance as a source of data.
Nevertheless, obtaining regular weekly reflections continued to be somewhat problematic. To offset a degree of irregularity with regard to the journals, the researcher structured them as interactive, with the participants mailing their reflections to the researcher and he writing his reactions and returning them to the participants, also by mail. With the participants' knowledge these interactive journals were photocopied by the researcher.

Thus, triangulation in the main study mirrored that in the pilot study. The data were again triangulated along two planes: methods of collection and sources within methods. Once again, the researcher was the sole investigator/analyst.

In addition to the case studies of Gina and Kathy, the researcher arranged to observe Diane six times during 1993-94. She was also interviewed on three of those occasions. The researcher was especially interested in the degree of any change in Diane's practice during the second year of her UCSMP implementation, in contrast to the change that occurred during her first year's implementation. Having been one of the teachers in the original UCSMP pilot implementation, and having reflected on the temporal aspects of change that occurred in his own practice, the researcher harbored a suspicion that Diane might well demonstrate more aspects of change during her second year of implementation than during her first.
Data Analysis

Strauss (1987) suggests grounding the theoretical constructs that emerge from a qualitative study in the data themselves. Moreover, in order to position oneself to do so, he suggests thinking about the data in terms of a triad: data collection, data classification, and data interpretation.

While there are no fixed rules or stated formulae to invoke in the analysis of qualitative data (Patton, 1990; Yin, 1989), there do exist general guidelines and suggestions for systematically making sense of such data. Those used in this study were coding the data, writing memos to oneself, and displaying the data.

Coding the Data

In order to facilitate the analysis of qualitative data, many experienced researchers suggest coding the data according to some set of classifications (Bogdan & Biklen, 1982; Glesne & Peshkin, 1992; Jorgensen, 1989; Patton, 1990; Spradley, 1979, 1980; Strauss, 1987; Yin, 1989). Such coding is absolutely essential if one is to follow Strauss' suggestion to ground one's theory in the data.

The researcher used the constructivist model for understanding teacher change (see Figure 3 in Chapter III on page 28) and his interpretations that unfolded as the data collection progressed as sources for the classification of data. The latter is in keeping with the constant comparison method of data analysis (Bogdan & Biklen, 1982; Strauss, 1987).

The constructivist model. All of the elements from the constructivist model suggested themselves as categories for data classification. Thus, the model itself yielded the following classes: peer interaction (PI); perturbation (P); reflection; (R)
change in practice: (CP) a vision (V); innovative materials, such as the UCSMP textbooks (TB); journal keeping (J), and inservice meetings (IM).

The Researcher's Interpretations. During both the pilot and the main study, many of the interpretations that the researcher made as the data collection progressed were based on some form of dichotomy. Thus, the researcher sometimes noted a tension between cooperative learning and whole-class instruction, as well as between conceptual understanding and procedural understanding. These tensions might be related to a more general dichotomy between a transmission-of-knowledge theory of learning and a constructivist theory of learning (T/C) and were so coded.

In one of the classrooms observed, the development of mathematical connections by both students and the teacher became a focal point for that teacher. Hence, mathematical connections (MC) served as a category.

The researcher noticed that much of the decision-making in the classrooms he observed is driven by management issues, often in conflict with pedagogical issues. Therefore, both management (M) and pedagogy (PD) were used as categories.

Throughout the early portion of the school year, two overriding sources of concern for each of the teachers studied were their students' perceived low reading comprehension levels and the unwillingness of their students to do homework. Thus, students' reading (SR) and their homework preparation (HW) were also used as categories.

Finally, at times the innovative UCSMP textbook and materials seemed to facilitate change. At other times, there was little doubt that the new materials acted to constrain change. Thus, the two poles of this dyad were coded as "agent of change" (AC) and "constraint to change" (CC).
The transmission of knowledge/constructivism dyad seemed to be the most general of the classifications. Therefore, each of these was further subdivided. Labeling transmission of knowledge and constructivism T and C for reference, the subcategories used were:

- Are examples, non-examples, and counterexamples provided by the teacher \((T_E)\) or by students \((C_E)\)?
- Are meanings and methods imposed by the teacher \((T_M)\) or negotiated by the class \((C_M)\)?
- Does the measure of authority and correctness reside in the teacher \((T_A)\) or in the mathematics community of the class \((C_A)\)?
- Are the students passively watching and listening \((T_S)\) or actively engaged \((C_S)\)?
- Since the UCSMP materials place a heavy reliance on calculators, is the decision to use a calculator made by the teacher \((T_D)\) or by the individual student \((C_D)\)?

In addition to coding the data in terms of how they fit into the theoretical framework of the study or the researcher's interpretations, the data were also coded according to their source. It will be recalled that the data were taken from three primary sources: the researcher's field notes of his observations of the three teachers, transcripts of interviews with them, and their written journals. The data were also coded with the date of the observation, interview, or journal entry.

Moreover, when two or more case studies are developed concurrently, it is important to keep the data separate and to develop the cases separately. Since the case of Diane in the first year served as a pilot for the main study, a preliminary development of the case of Diane was written at the end of the first year.
Subsequently, the data for the three cases were recorded and stored in separate files, and every effort was made to develop these cases independently. Once the interpretation of the three cases had progressed to the point where each case exhibited a degree of uniqueness, cross-case analysis for similarities and differences was possible.

**Memo Writing**

Writing memos to oneself or keeping a reflective field log have been posited as a means of developing and recording preliminary interpretations and analyses of qualitative data (Glesne and Peshkin, 1992; Strauss, 1987). These written reflections are seen as a means of linking data across sources.

The researcher incorporated memo writing, of a sort, across each of the sources of data. Memos, or observer comments, were written directly into the field notes of the observations of each teacher. These comments frequently fueled the development of subsequent interview guides that were used with that teacher. The researcher himself transcribed the audiotapes of those interviews. As he did so, questions not asked, possible misunderstandings, and alternative interpretations frequently suggested themselves. These were typed in bold-face directly into the transcripts and were frequently referenced in the writing of later interview guides. Finally, the interactive journals kept by the teachers during the main study, by their very nature, demanded that the researcher write his thoughts or questions regarding the teachers' reflections into those journals.

These written comments, questions, guesses, hunches, and preliminary interpretations were invaluable in the data analysis and interpretation phase of the study. Inasmuch as the constant comparison philosophy, applied to the analysis of these data, implies that interpretation and analysis must be ongoing during the study,
the researcher is really left with little choice but to somehow record such thoughts. To rely solely on memory is to risk missing key factors in the study as they unfold.

Displaying the Data

Analogous to the notion that "you are what you eat," Miles and Huberman (1984) claim that, as a qualitative researcher, "you know what you display" (pp. 21, 22). Strauss (1987) notes the need to thoughtfully and systematically analyze the data. Among the ways one might do so, Glesne and Peshkin (1992) and Yin (1989) suggest organizing the data into matrix arrays. The researcher used the strategy of making two printed copies of each data entry: one for his archives and one that was physically cut up into fragments that were coded and assembled and reassembled into arrays in the search for patterns, connections, and meaning.

In the final analysis, it is the researcher's own scholarly rigor in the analysis and interpretation of qualitative data that secures the reliability of that process (Patton, 1990; Yin, 1989). As Patton observes, "There are no absolute rules except to do the very best with your full intellect to fairly represent the data and communicate what the data reveal, given the purpose of the study" (p. 372).
The Researcher

Since the qualitative researcher who does her or his own fieldwork is both an instrument of data collection and the interpreter of those data, it is important to describe the researcher in terms of background, interests, beliefs, and possible biases. Peshkin (1982) hypothesizes the existence of strong relationships among the researcher, her or his research interest, the means of inquiry the researcher employs, and the results ultimately claimed. From such a perspective, "those of us who are doing ethnographic research - those of us who are committed to objectivity but still acknowledge the subjective nature of our work - understanding the association is essential" (Peshkin, 1982, pp. 50-51).

By so describing the researcher, it is hoped that the reader will gain insights into his particular perspective. Moreover, it is hoped that in the telling, that perspective will become more transparent to the researcher himself. Therefore, he will tell his own story:

My interest in teacher change no doubt derives from the many years that I spent in the classroom myself. From the vantage point of the "typical" classroom teacher, change is difficult to come by, given the nature of the workplace of teaching. The typical teacher is likely to ask two questions about change: when and how? This suggests to me that my research into change in teaching practices had better not unduly burden my teacher participants with further time constraints and ought to offer them something in terms of support for their efforts.

I worked as a classroom teacher of secondary mathematics for 24 years in the district where this research was conducted. Of course, during that time I had many
contacts with colleagues within the district. Obviously, I also taught a large number of students, some of whom themselves are now teachers in this district. These facts underlie the ease with which I gained and maintained entrée with the teachers whom I studied.

One of the most important professional contacts that I made over the years in this district was with Ms. Riter, the Director of Mathematics for the district. I have known her for over 20 years, and she has always been supportive of my efforts in mathematics education. This was true when I was a teacher, and it was also true when I returned as a researcher. Ms. Riter was most helpful in supporting my request to the Superintendent of Schools for permission to conduct educational research in the district. Her knowledge of both the UCSMP implementation and the teachers who would be the implementers was invaluable in helping me to identify teachers to study and to gain entrée with them. In the cases of Gina and Kathy, she made the initial contacts and introduced my study to these teachers in a nonthreatening, almost casual way.

In the case of Diane, during her first year of teaching, she was assigned, part time, to the school where I worked. Although we were not well-acquainted, the fact that we were acquainted probably helped me to gain entrée with her.

While I had not met Gina prior to my first visit with her in April 1993, I later learned that one of her best friends, a colleague with whom she works everyday, is a former student of mine. Again, I believe that this helped me to gain entrée. Moreover, I believe that the rapport I share with her friend and my former student carried over somewhat to our own developing relationship.

I had also not met Kathy prior to my initial visit with her in September 1993. However, one of the assistant principals in her school, Laree, is a friend and colleague
of mine. For some years, the Director of Mathematics was fond of summoning the mathematics department chairs from all of the secondary schools in the district to regular monthly meetings. Laree and I originally met at those monthly meetings. We also have co-presented several workshops for secondary and middle school mathematics teachers in the district. I am sure that my professional relationship with Laree helped me to gain entrée with Kathy. I am also sure that Laree's continuing interest in my research has helped me to maintain entrée with Kathy.

There was one additional factor that I believe was instrumental in my gaining and maintaining entrée with these three teachers. I was one of the three teachers in the original pilot implementation of UCSMP in this district. I had taught with the UCSMP materials for two years myself, and these teachers knew that. I believe that this helped to make me more of an experienced colleague than an educational researcher in their eyes.

Of course, it does the researcher no good to gain entrée if he or she does not maintain entrée. In case studies, this notion of "gaining entrée" is a continuing process. Having been a classroom teacher for 24 years myself, I am well aware of the potential for disruption to a participant teacher's workday that inheres in research such as mine.

Therefore, I made it my business, throughout the study, to be as unobtrusive as possible in the working lives of these three teachers. I always let them decide, within the constraints of their workday and my data collection requirements, when the best times for observations and interviews would be. A good example of my attempts to minimize the disruption of their lives that my research might cause occurred during my scheduled visit with Kathy in October 1993. When I arrived at Kathy's room that day, she was noticeably upset about something. Without hesitation, I noted that she seemed
preoccupied, and asked if she would like to forego the observation and interview that day. Her immediate affirmative answer was evidence enough that I had chosen just the right course in that situation.

Maintaining entrée with these teachers involved more, however, than merely being unobtrusive. I think, more importantly, that it was a matter of confidence. As their confidence in me grew, our professional relationships blossomed. In order to develop that confidence, throughout the study I attempted to position myself as a partner and colleague in their minds. I did this by being non-committal with regard to their classroom practices, by offering advice or assistance only when asked, by demonstrating my confidence in them as professionals, and by showing genuine interest in their work.

Conclusion

The nature of the questions in this study gave rise to the selection of a qualitative methodology. In particular, to understand the process by which teachers make changes in their practice of teaching requires immersing oneself in the naturalistic settings in which those teachers find themselves. As Rist (1983) observes, "the most powerful and parsimonious way to understanding human beings and the social environments they have created is to watch, talk, listen, and participate with them in these environments" (p. 12). The qualitative research methods that were employed provided just those means.
CHAPTER V

THE CASE STUDIES

"Those who can, do. Those who understand, teach."

- Lee S. Shulman (1986, p.14)

During the 1992-93 and 1993-94 school years, I followed Diane and her attempts to implement the UCSMP Transition Mathematics curriculum in her eighth grade classes. During the 1993-94 school year I similarly followed Gina and Kathy and their attempts to implement a UCSMP curriculum in their classes. These are stories of frustration and exhilaration, of confusion and order, and of failed effort and accomplishment. To a great extent, they are stories of professionals in action.

The Case of Diane

The 1992-93 school year was Diane's fifth year of teaching, all in the same school as a seventh and eighth grade mathematics teacher. Diane works in a grade K-8 magnet school for the study of the Italian language. The intent is that the school will attract students from throughout the district who wish to study Italian. Although Italian is indeed taught in this school, the reality is that most of its students live in the surrounding neighborhood. The school was built in the 1950s to serve a predominantly Italian-American ethnic neighborhood. Today, the neighborhood has a diverse ethnic mixture, including Hispanic, Asian, and African-Americans, as well as the remnants of the earlier Italian-American community.

54
The neighborhood itself is one of the oldest in the city and the signs of urban blight are readily apparent. One of the houses directly across the street from the school is boarded-up and shows signs of recurrent vandalism. On the other hand, three houses just down the street from the school are well-kept and freshly painted, an oasis in the midst of urban decay. It is within such a setting that Diane spends her professional life.

Although Diane has taught only in this urban setting, her roots lie in rural America. She grew up and received all of her pre-college education in a small school district in a farm community about 120 miles from the city in which she now works.

Diane's collegiate education, both graduate and undergraduate, was obtained at a large state university which is also a research center. She holds a bachelor's degree in chemical engineering and a master's degree in mathematics education. When I asked Diane about her change in career plans, she indicated that the decision to study engineering was probably a mistake. Her answer provides insight about the basis for her decision to enter teaching:

I finished my degree in engineering and then couldn't figure out how I ever thought I could enjoy going out and being an engineer. So it was at about that time that ... that someone asked me to tutor their son. So I did that and I realized I had made not my best decision, so I went back to graduate school.

As to her decision specifically to become a mathematics teacher, that choice seems almost to have been inevitable. She told me, "I guess I'd have to say that it was my favorite subject and something I feel is really valuable."

Diane is the only teacher with secondary mathematics certification in her building. In 1992-93, her teaching load consisted of the two eighth grade classes in which the UCSMP Transition Mathematics curriculum was implemented and three seventh grade mathematics classes that did not use UCSMP materials. In addition, during a 45 minute period daily before the start of the normal school day, Diane taught
three eighth-grade students the district's regular ninth-grade mathematics curriculum, an integrated course in beginning algebra, informal geometry, symbolic logic, probability, and data analysis. She did this on a voluntary basis.

In 1993-94, Diane's teaching load was the reverse of her load during the previous year: three eighth grade UCSMP Transition Mathematics classes and two seventh grade non-UCSMP classes. Once again, she voluntarily taught the same ninth grade curriculum to four students in the morning before regular classes began.

Whenever I visited Diane during the 1992-93 school year, I observed both of her UCSMP classes and one of her other classes. During 1993-94, I observed only two of her UCSMP classes and none of her other classes.

As I followed Diane's efforts to implement a UCSMP curriculum for the first time, several themes began to emerge:

- Diane is a reflective teacher.
- At the beginning of the school year, Diane was disposed to making changes in her practice.
- Diane is a structured teacher.
- There is a developing tension in Diane's practice between the needs for her students' conceptual and procedural understanding. This tension is not yet resolved.
- Diane is possibly beginning a transition from all teacher imposed meanings to some negotiation of what have been called "taken-as-shared" meanings (e.g., Wood, Cobb, & Yackel, 1991).
- There is an ongoing development of mathematical connections in Diane, her practice, and her students, and the UCSMP text is both a source and a catalyst in the process.
• The UCSMP text has been both an agent of, and a constraint to changes in Diane's practice.

To one degree or another, each of these interpretations remained viable during the second year of Diane's UCSMP implementation. The rest of her story will be organized around these seven emergent themes.

*Reflective Teacher*

Diane has consistently shown evidence of a reflective practice. Two of her early journal entries hint at such reflectivity.

In October 1992, Diane wrote about reading William Glasser's *The Quality School* and extrapolating ideas for her practice from the book. A November 1992 journal entry indicated her concern about her students lack of homework production. She described discussing the problem with colleagues as part of her search for a solution. Both of these gestures, outside professional reading and discussion with peers of the problematic in one's work, provide clear evidence of Diane's reflective practice.

To further buttress this claim, it should be noted that Diane is a member of NCTM, and that she subscribes to the *Journal for Research in Mathematics Education*, which she reads with a particular eye to the implications of research findings for the classroom. Again, I would argue that both of these factors point to Diane's reflectivity.

Throughout the 1992-93 school year, Diane attended two sets of inservice meetings. One set consisted of teachers who were implementing the various UCSMP curricula. They met to discuss their impressions, successes, frustrations, and the like. The other was a workshop setting, the topic of which was cooperative learning. Diane's interactions with peers at these meetings seem to have fostered her reflectivity.
In November 1992, Diane wrote in her journal concerning a small change in her routine at one of the UCSMP inservice meetings:

This past weekend I went to a UCSMP inservice. I decided to sit with different people to hear how it was going with them. The people I sat with were very cynical. I was surprised and I also realized that everyone expresses frustration differently.

Earlier in the month, I had asked Diane if she had found any value to the UCSMP inservice meetings:

It's been helpful to talk to other people; to have other people say, "Oh yeah, that's been happening to me, too." That part has been helpful. And hearing other people's ways of managing the program and trying to get the students involved has been helpful. You know, just the sharing of ideas, I think, was good.

In January 1993, I asked Diane about the cooperative learning inservice meetings:

The teacher who's presenting gives us a broad idea of how she uses it, and then you have to really take the stuff further and apply it to your own class. I think it will be helpful in the sense that there will be more options, more things to try.

I would argue that each of these vignettes demonstrates some degree of reflective activity that followed Diane's interaction with her peers.

In December 1993, during her second year of UCSMP implementation, I asked Diane a fairly whimsical question: If you had a mathematics educator "Genie-in-a-Bottle" who could grant you three wishes, what would they be? In particular, I believe that her second and third "wishes" demonstrate continued reflective activity:

I would like students who are interested and motivated and cooperative and want to learn. That would be the first thing. The second thing I would want would be the ability to take more risks with my teaching, and go out on a limb and try something creative - really creative. And the third ... the third, I don't really need a genie to do it. It just involves me doing it. I think I would like a stronger support group; a larger, more active network of friends who are willing to honestly discuss teaching mathematics and working together.
Disposed to Change

A major basis for my interpretation that Diane was predisposed to making changes in her practice is her reflective practice. However, reflectivity is but a necessary, not a sufficient condition to a disposition to change. To infer that Diane was predisposed to change in her practice requires evidence of favorable attitudes toward change that were present at the beginning of, or very early in the study. Three embodiments of such favorable attitudes appeared during the first month of the study, and a fourth appeared somewhat later but recurred throughout the balance of the first year of the study.

Diane provided an initial glimpse of her predisposition to change. In her very first journal entry, dated 20 September 1992, she wrote, "I still feel really excited about the book and the material. The goals of the program are exactly in line with how I feel and have felt for a long time."

Then, about two weeks later in our first interview, I asked Diane how she felt about UCSMP's heavy reliance on students' use of calculators.

I'm for them using calculators. I feel that if they can use a calculator to help them get past the mechanical part, but understand what they're doing, then I want them to do it because it will keep them more interested in math for a longer amount of time.

What is the more remarkable about Diane's easy acceptance of her students' use of calculators is that, prior to the UCSMP implementation, she had not used calculators with her students. This fact was confirmed by my observations of the one non-UCSMP class. Although there was a class set of calculators available for possible use, I never saw those students use them, and Diane only reported one or two instances where she had used the calculators in the non-UCSMP classes when I was not there.

Also in that first interview, I asked Diane about her response to an item on the survey she had completed for me in June 1992. The item concerned cooperative
learning groups, and Diane had indicated disagreement with the statement: Students working in cooperative groups can learn just as well as from whole class instruction. I asked Diane to explain her response. She replied, "Well, I guess in my experience, with these students, at least, I haven't come up with a way yet to get them to work in small groups that's productive." When I probed further as to her possible acceptance of a cooperative learning format, if she could be shown ways to make it work in her classroom, Diane agreed that she would definitely be willing to give it a try.

During the next five weeks, Diane turned inclination into action. A journal entry dated 30 October 1992 ends with a revealing notation: "In the course of the last three weeks I had the students in the sixth period class doing some group work. ... I'll continue to try this and work at making it more and more beneficial for all." On 11 November 1992, she wrote of taking steps which kept her new interest in cooperative learning alive for the rest of the school year: "I've also been reading some books on learning teams, and I've signed up for a cooperative learning inservice. I plan to really work at using these strategies in my classroom." The most significant point about this transformation from a somewhat negative attitude toward cooperative learning groups to an active interest in seeing the strategy actually work in her own classroom is that it occurred within the span of five weeks. From my perspective, this clearly demonstrates Diane's predisposition to change.

There is one further aspect of Diane's practice that hints at such a predisposition. The months of October and November 1992 were a period of what Diane has described as confusion, frustration, and disappointment. Two major problems had surfaced in her UCSMP classes: Her students were having grave difficulties reading the textbook independently, a major component of the UCSMP approach, and her students were not producing very much homework.
These problems led Diane to seek to find ways to facilitate her students' attempts to read their textbook and ways to encourage them to produce more homework. As the year progressed and her students' reading proficiencies seemed to improve, Diane changed her practice to accommodate the changes in her students. Thus, I saw a progression from students reading orally in a whole class format, to students reading individually and silently as Diane modeled some reading strategies for them, to students reading independently outside of class.

Diane's attempts to foster greater homework production from her students were embodied in several small assessment changes that she incorporated over the course of the year. These ranged from homework "bonus points" to daily graded bellwork based on the previous night's homework assignment.

The point is that Diane continually changed some of her management routines as she constantly struggled with these two problems. Again, this confirms Diane's predisposition to change her practice.

*Structured Teacher*

One facet of Diane's practice suggesting that she is a structured teacher surfaced during my initial observations of her work. I noticed that she frequently made instructional decisions that were based on management concerns, rather than pedagogical concerns. An entry from Diane's journal in September 1992 clarifies the basis of that observation: "My discipline and control has seemed to have disappeared, with all these new procedures. I'm sure it will return, but its absence makes me frustrated." Just a week later, she wrote, "I'm feeling lost in this new format. The feelings I have aren't that dissimilar from my first year of teaching." Thus, it seems that Diane's early attempts at implementing the UCSMP curriculum caused her to feel
that she was somewhat out of her element; somehow out of touch with her accustomed structured format.

I do not mean to imply that it was only the UCSMP implementation that caused these early frustrations. One of Diane's classes was particularly troublesome:

I'm very overwhelmed with the sixth-period class. I feel it's an uphill climb everyday in class. I use up 15 minutes of class getting them settled. I then feel frustrated by the time lost and the amount of work to get through in the remaining time.

Small wonder that I often observed Diane spend large blocks of instructional time on management issues. This practice would continue until, around the middle of the year, her students began to take an interest and a more active part in their mathematics lessons.

One might argue, however, that none of this by itself is evidence of a structured teacher. Clearly, it is a responsibility of the teacher to provide a classroom atmosphere conducive to learning, and Diane may have been merely doing just that. There were other signs that led me to this interpretation.

In my fieldnotes, it was my habit to note the format that Diane used at the beginning of each class that I observed. Every class that I saw began with the students working on four or five "bellwork" exercises. While her students worked on this assignment, Diane would circulate among them, checking and recording their homework preparation. Her procedure never varied.

In fact, over the course of the two years during which I observed Diane's classes, the only features of her opening activities that showed any deviation whatsoever surfaced during 1993-94, her second year of UCSMP implementation. These were a tendency toward fewer bellwork questions (typically 2 or 3 rather than 4 or 5) and the instruction to students to check their homework answers against a prepared key which was usually on a transparency on the overhead projector.
Nor did Diane vary her approach to the review of either the bellwork or homework during the first year that I observed her work. Typically, students would be asked, or they would volunteer, to place their solutions on the chalkboard. Explanations, if any, were always provided by Diane.

Often, I noticed that Diane, in providing an explanation, would provide her students with a structure by breaking the question into a number of sub-tasks. In a similar manner, Diane imposed a structure on her non-UCSMP students' class notebooks. Whenever they made notebook entries, Diane would make references like, "... the next item in your outline is number 9; Solving multiplication equations involving fractions," while simultaneously writing this on the board.

In all of these ways, then, Diane gave evidence of being a structured teacher. I finally asked her about that, in our sixth interview, which was conducted on 28 April 1993. After suggesting that she is a structured teacher, I also posited a possible causal factor: her engineering background. When I asked if that sounded reasonable, Diane replied, "It may ... and just my personality. I think that's just generally the way I operate, period!"

_Tension Between Forms of Understanding_

The tension in Diane's work between her belief in the need for her students to develop both a conceptual and a procedural understanding of mathematics was apparent from the beginning of the study. On my first visit in October 1992, I noted from my classroom observations of Diane that she focused on procedures, although she seemed to want to build some conceptual understanding to help her students with procedures.

As previously indicated, during each of my visits, I interviewed Diane following my classroom observations. The interview on that first visit yielded Diane's viewpoint regarding the process-product debate: "I don't feel the right answer is the
most important thing. I think the process is." Later in that interview, Diane discussed non-standard problem solving and open-ended questions as important features of mathematics instruction. She also expressed a belief in the importance of developing original thinking in her students:

The way I see it is there's two kinds of thinking. I think there's thinking within boundaries, and there's lots of that kind of thing that goes on that students are asked to do, and then there's thinking that goes outside of the boundaries. And I think that more realistically ... I think that the kind of thinking that we have to prepare these students for is the kind that goes on outside the boundaries.

This dichotomy persisted throughout the 1992-93 school year. Although Diane asked for student explanations during my November observations and provided conceptual examples and explanations during lessons in December, in an April lesson there was also a clear focus on the procedure involved, with no attention to any conceptual links. Her ambivalence is perhaps epitomized by this pair of entries in my fieldnotes, both from my January visit, one from each of her UCSMP classes:

1. I must note that she stressed understanding the rules throughout. Moreover, she also noted that, if they did not need the "rule" to understand the process, they did not need to use it.

2. In considering the last bellwork question, she seems interested in understanding, but not of the concepts. It is an understanding of the procedures that gets the focus.

During the January 1993 interview, we touched on the concepts/procedures controversy. When I asked Diane which she thought should be the focus of instruction, her response indicated some confusion on her part: "I think that there's ... I don't know, I ... I don't know that I have a real clear philosophy about it, first of all." However, she did go on to describe her sense of the relative value of concepts vis-à-vis procedures: "You can know a procedure and not know the concept. And you can know a concept and be able, I think, to figure out a procedure. So I think, I think
it's more useful if a student knows a concept." Perhaps by asking Diane to explicate a philosophy, this exchange caused her to think deeply about this issue for the first time.

Finally, I asked Diane directly to address the following statement in our sixth interview in April 1993: There is a developing tension in Diane's practice between the need for her students' conceptual and procedural understanding. She responded: "I would say that's definitely accurate. I think I constantly struggle with trying to help a student see why it is that way versus just doing it." And when asked if she could see how that tension had manifested itself that very day during my classroom observations, she identified an instance where she had provided conceptual links for a procedural activity and one where the focus had been procedural knowledge with no conceptual links at all.

This tension persisted into the second year of the study. Indeed, an exchange from an interview in December 1993 suggests that such a tension might be difficult to avoid:

Interviewer: Last year, I made the interpretation that there is a tension in your practice between the need for both your students' conceptual and procedural knowledge of mathematics. I'd like you to tell me whether you see that as still valid, and why.

Diane: It's still there. [laughs]

I: Can you think of an instance where you bumped into that, that you were aware of?

D: [very long pause] I'm thinking in Transition Math, we were doing the converting of units, and I want them to understand why, but they want to know how. You know, why does it work? Why can you do that? What's that mean? But they're more like, "Well, just tell me how to do it."

I: So they're eager for the procedures, …

D: Yeah.

I: … and impatient about the conceptual understanding.
D: Right.

The fact that this tension exists at all, together with the knowledge from my observations that Diane is quite capable of providing conceptual examples for her students cause me to believe that the source of this tension has nothing to do with the knowledge base that Diane brings to her work. Rather, it seems to spring from two places: a sense of lack of time as an instructional constraint and some confusion as to the nature of students' mathematical understanding.

Regarding the former, in February 1993, Diane told me:

And sometimes, I feel the pressure of the time, I think, more than anything else. You know, I think the "why" is wonderful, but some days I don't feel that there's enough time ... in order to get to the "why" and then I feel like we didn't get it accomplished.

Also in that interview, Diane provided an inkling of some possible confusion that she held regarding student understanding:

Sometimes I have to settle for "what," because I get the feeling from them that they're not ready to understand "why." They don't have enough background or enough basic understandings to support the "why." At this point, "what" is the reason.

A month later in March 1993, that confusion again surfaced as Diane attempted to explain her conception of students' mathematical understanding. Following a nervous laugh and a long pause, she said:

Well, at one end of the spectrum, I see it as, maybe at the most idealistic end or the most advanced end, understanding it means being able to explain it in their own words, to be able to use it, and to be able to apply it to things, I guess that's what I mean. On the other end I think I see students who can understand things and can ... can do it. Maybe they can't put it into words and explain it, but they can do it. That's more a procedure than a concept. I don't know ... I guess I'd have to think about that one.

Thus, the confusion remained. However, the fact that we did address the issue may have helped Diane to consolidate her thinking. In a journal entry dated 23 April 1993, she wrote:
I think understanding is demonstrated by use, or explanation, or application. When a student can use a concept there is some level of understanding, and when a student can apply the concept to a new or unusual situation, there is an even higher level of understanding.

During the second year of her UCSMP implementation, this tension between conceptual and procedural knowledge remained a concern for Diane. She said as much in the exchange from the interview in December 1993 that was quoted on p. 60.

But I detected a subtle difference in Diane's response to this tension during the second year. A good example occurred during a lesson in October 1993 that concerned multiplying by $\frac{1}{10}$ or .1. My fieldnotes contain the following observation:

She continues to stress their making connections among the various "rules" that they are generating. I think that I am seeing more of a stress on concepts than procedures, and this was a difficult lesson with which to do that. This lesson could lead directly to rules and procedures, if the teacher were so inclined. Diane has not done so; she is focused on the conceptual underpinning, and determined to help her students find an understanding through conceptualization.

While I could not always make such observations, sometimes, in fact, witnessing just the opposite sort of focus, it did appear that there was a greater emphasis on conceptual knowledge than on procedural knowledge in Diane's teaching during the second year of the study relative to the first.

In March 1994, toward the end of that second year, I asked Diane if she would characterize the tension between conceptual and procedural learning now as greater than, less than, or about the same as that prior to her UCSMP implementation. While she was reluctant to commit herself on this, her response does imply some growth in her knowledge about herself as a teacher: "That's an interesting question. It's hard to say, because I'm so much more aware of it now. It may have been there, and I didn't know what it was or didn't notice it. Now, when it's there, I know it's there; partly because of our dialogue about it."
Transition to Taken-as-Shared Meanings

Wood, Cobb, and Yackel (1991) suggest the negotiation of taken-as-shared meanings as an alternative to teacher imposed meanings. In this way, the mathematics classroom might be transformed into a mathematical community. Simon and Schifter (1991) describe several traits of such classrooms:

- The teacher is no longer the transmitter of knowledge, but is a facilitator of learning.
- The teacher avoids commenting directly on the correctness of particular student ideas, instead letting those ideas stand or fall on their own merits.
- No longer is the teacher the sole judge of mathematical validity. That role now passes to a mathematics community, of which the teacher is but one part.

My first observations of Diane in early October 1992 made it clear that she was the authority for mathematical correctness in her classroom. In each of the three classes I observed that day, when the bellwork and homework exercises were reviewed, she always confirmed student responses with, "Correct," or, "Good!" or some such remark. She was quite sensitive to incorrect or partial responses posed by students and was somewhat accepting of them. Generally, she would open a dialogue with the student so as to guide her or him to the "correct" answer. In so doing, it was clear that Diane was imposing her own methods and meanings.

At least two things occurred during my visit in November 1992 that caused me to focus on this point through the remainder of the study. Diane's non-UCSMP class began that day with a review of the bellwork and homework that was substantially what I had seen a month earlier.
When the actual lesson began, however, I noticed characteristics of a negotiation process toward some shared meanings taking shape for the first time, but these were imbedded in a lesson that was filled with teacher imposed meanings as well. The ambivalence of the lesson is exemplified in the following notation from my fieldnotes: "She asks if anyone can explain, *in their own words*, what it means to evaluate an expression. She waits [perhaps 5-6 sec], then 'guides' the class to *the response that she wants*." Toward the end of that class, Diane assigned an example for the students to work on in pairs. As they were finishing this task, she asked one pair to explain their solution. Then she asked *someone else* to justify the results.

Later that day, in one of the UCSMP classes, Diane was discussing with her students the key ideas in a lesson that they were reading together from the text. Their discussion led to this excerpt from my fieldnotes: "The first key idea that they have identified is area. Together, they negotiate a meaning for area. She is quick to use their suggestions, and *they come to an agreement that is not quite the book definition.*" Thus, in small steps like this, I suspect, was born the negotiation process in Diane's classroom.

Although she continued to the end of that first year usually passing judgment on student responses to homework or bellwork exercises, I saw a few instances where she did not. Moreover, student responses during lesson segments were another matter indeed. An exchange that occurred in one of the UCSMP classes in January 1993 is typical. Drawing again from my fieldnotes, I recorded the following: "Diane asks what they think some of the main ideas of the lesson are. A student suggests, 'Absolute value,' and without comment, she has them write that term in their notebooks. [Does this indicate a subtle change in the authority for correctness?]"
This is not to suggest that she always instigated a process of negotiation in her lessons thereafter, nor even that she frequently did so, but my fieldnotes from January through April 1993 are littered with the word "negotiate." A passage from the fieldnotes of my March visit is indicative of the kinds of things that Diane had worked into her classroom practice by year's end: "She again explains what the student had apparently done to solve the problem, but she passes no judgment as to correctness (i.e., she let the work stand on its own merit)."

Any nagging doubt that might have lingered regarding the substance of the transition I thought I was witnessing was dispelled during my February 1993 visit. In the non-UCSMP classes that day Diane had her students working in groups of three or four on a review sheet in preparation for a test the next day.

Diane was adamant in her instructions to them that she would not answer any questions herself about the mathematics content if there was someone in the group who could do so. In fact, I did not hear her answer any such questions. All of her interactions with students during this activity were either motivational or concerned their cooperation with each other.

At the end of the class period when the students were once again in a whole-class format, Diane gave them both positive and negative feedback regarding their cooperative skills. The mathematics content was never mentioned.

The implication of this is quite powerful, I think. The students had negotiated their own understandings of the material. On that particular day, during that particular activity, they were the mathematics experts. This was a radical departure from Diane's past practice.

We addressed this issue during the last two interviews of the 1992-93 school year. In March, I described two hypothetical teachers to Diane: "Teacher A asks a lot
of questions to help students to see the meaning of mathematical concepts, as Teacher A understands them. Teacher B asks a lot of questions to help students build their own meaning of mathematical concepts." I asked Diane which of these two approaches she saw as being closer to an ideal. Following a long pause, she replied:

My initial reaction is B. [Another long pause] Because I think when it's your own understanding, it makes more sense to you and it's more likely that you'd be able to use it and apply it and do those things that I just have been describing that show you understand something.

When I asked Diane where she saw herself in relation to these two hypothetical cases, she said: "Probably closer to A. Somewhere between, but closer to A." And where would she like to see herself? "Probably closer to B. As close to B as I probably am now to A."

Finally, in April 1993, I asked Diane directly about what I had interpreted as a possible transition from all teacher imposed meanings to some negotiation of taken-as-shared meanings:

Yeah, I would say that that's true. I think I do more of taking the students' input and working with that. I think that I did that today when we were working on that...in the second class, when we figured out we had to subtract ... well I don't know, maybe I was more going in that direction, but trying to help them see why it wasn't working. Well, I was trying to use whatever means I could to help them to see that we had counted some things twice. I think that was good for me, and I think it's good for them to see me struggle some once in a while. At any rate, I think I do more of that now, than I did before. Definitely!

Diane's transition toward the negotiation of shared meanings with her students continued into the second year of the study. The fieldnotes from my observations of Diane during the 1993-94 school year contain numerous references to such practices.

In September 1993, in describing a problem solving activity in one of her classes, I noted that "the first thing they discuss is the meaning of the phrase 'a dinner party for 22' that occurred in the problem statement." In another class later that day, I made note of something that was a rare occurrence the previous year: "Diane allows a
student to explain her own solution." In October 1993, I wrote the following into my fieldnotes:

Diane zeros in on one student who answered incorrectly; she will not let her off the hook, and helps her to explain her own thinking. At the end of this sequence, this same student sees a pattern, which she is able to articulate herself.

As the second year progressed, the nature of the bellwork and homework review in Diane's classes began to change dramatically. Whereas during the previous year, she provided nearly all of the explanations for bellwork or homework questions herself, beginning in December 1993, I noticed that she began to use questioning techniques so as to draw the explanations from the students themselves. I also noticed that she no longer seemed to be validating her students' responses. Later during that same visit in December 1993, I wrote: "Again, throughout, she usually accepts their responses without comment. It almost seems that she is consciously trying to avoid validating their responses herself." Finally, during the interview that day, I asked Diane to recall the interpretation that I had made the previous spring that she seemed to be in a transition toward the negotiation of shared meanings with students. I asked if that interpretation still seemed valid. She replied:

Yeah. It does; I think it happens throughout the course of the year. I think I get more towards that way as I get to know the kids better. So I've noticed it start to creep in again. That I want them to make meaning. Like when we go over the bellwork, I'll just let them decide whether the answer is right.

It is in this area that Diane has shown perhaps the most change, and much of that change seems to have been consolidated during the second year of her UCSMP implementation.

*Development of Mathematical Connections*

Beginning at about the middle of the first year of the study, there was an unexpected change that Diane noticed, first in her students, and then in herself.
It was related to an entry in her journal dated 8 January 1993: "I liked the presentation of the material in lesson 5-2. Writing the pattern for adding fractions with like denominators was a good carry over from chapter 4. I also liked the way it was tied into the work with measurement."

Three days later, during our third interview, Diane attached a label to what she had written about:

I like the way things are tying together and I like ... I like its cohesiveness, you know, that it's connecting things, where I, in the past, teaching the other eighth grade curriculum, had difficulty connecting it in that way. And I think it's connecting it in a neat sort of way, and in an understandable kind of way, as well.

Also during that interview, Diane related an incident that had occurred in one of her UCSMP classes that she had written about earlier in her journal. Her verbal description is the more informative:

I had put a pattern for the additive identity, on the board, and I was asking each one of them to give an instance of the pattern, and one of them said, "Can't you do the same thing with 1?" And I said, "Well, what do you mean?" And he said, "Well, you get the same thing with 1." So we kept talking about it and they were connecting additive identity and multiplicative identity, which I thought was really neat.

It seemed important to track this development. A month later, in February 1993, I asked Diane if she still felt that the UCSMP text was connecting ideas for her students. She replied, "Yeah, I do. It seems that the broader picture is being painted much clearer than it was in the past. I think some of the connections are a result of the reading and the way that it's written."

By the end of the 1992-93 school year, Diane had noticed that her students were not the only ones who were making new mathematical connections:

I think I always wanted to have ... to be able to make connections better, but didn't always have the resources to do that. Or the time. And this seems like it's - the UCSMP text is laid-out so that it's pretty much right there. And so I've been taking from that, and seeing myself more connections, and being able to make more connections for the students.
Although the fieldnotes of my observations of Diane's classes during the second year of the study do contain some references to mathematical connections, there was not the focus on this factor that I expected. In December 1993, I asked Diane if it still seemed that mathematical connections were being made by both her students and herself. Following a fairly long pause, she replied:

In terms of the students, I haven't noticed it as much. Of course, it's early. So maybe it's going on, but it just hasn't come to my attention yet. For me, I feel that it's not happening as much as it was last year. Of course, I've been through it once already. I made some connections last year, so obviously, they're not there to make for the first time this year.

We both agreed that, since this notion of mathematical connections had not become a real factor until well into the previous school year, it was perhaps too early to expect to see much of it during the current one.

However, mathematical connections never did rise to the same level of prominence that they held the previous year. In March 1994, I again asked Diane about the dearth of mathematical connections in her current Transition Mathematics students:

Yeah, that still remains to be the case. I don't know ...; I base it all on just their behavior, and their not willing to put forth the energy to do the work. I feel like I'm making some connections, though, which is kind of fun; they might not be, but I am.

_An Agent of Constraint to Change_

Throughout my study of Diane's teaching practice, I read, saw, and heard many things suggesting that the innovative UCSMP textbook and materials both precipitated and inhibited changes in Diane's practice. There were five areas of change which the new materials seem to have facilitated: use of cooperative learning groups, transition to taken-as-shared meanings, development of mathematical connections, use of reading as an instructional strategy, and a changing role in the classroom.

_Cooperative learning groups._ In a previous section, the genesis of Diane's interest in cooperative learning groups was traced. She continued her attempts to
implement this strategy, with some success, through the end of the second year of the study. In an interview in April 1993, I asked Diane if there were any ways in which working with the UCSMP materials had influenced changes in her practice. She said, "I think that through the UCSMP, I started to use cooperative learning more. That was one thing that I had wanted to do, although I tended to use it more with the seventh grade [her non-UCSMP classes] this year." The reason for her more frequent use of cooperative group strategies in her non-UCSMP classes will become apparent when we examine constraints to change.

*Taken-as-shared meanings.* The possibility of this transition has already been discussed at length. I asked Diane in the April 1993 interview if she was aware of any source for this transition to a process of negotiation:

I think it's probably a result of the UCSMP, in the sense that I'm doing less lecturing with them. So they're having more ownership in learning the material, which causes them to be more interested and to know more. And they're struggling more to have to do it ... it's not just - this is how you do it - that part is gone.

*Mathematical connections.* That the UCSMP implementation was the source of the development of mathematical connections in Diane's practice seemed clear to me from the way that development unfolded. An entry from Diane's journal, dated 23 April 1993 confirmed UCSMP as the source: "I've been noticing that UCSMP has helped me be interested in connecting ideas together more for my seventh graders. I've felt more willing to try to make math apply to their lives."

*Reading as an instructional strategy.* The UCSMP textbooks were designed to be read by students. Most, if not all, of the questions, exercises, and problems in these books assume that students have done so (UCSMP, 1989).

During Diane's first year of UCSMP implementation, her frustration, struggle, and eventual success in implementing reading in her instruction has been discussed
earlier. Its importance, however, goes beyond the mere fact that it is in itself a mark of change. In Diane's view:

The whole reading aspect has entirely changed my way of teaching. I wouldn't think of having my seventh graders open up their textbook and read it. You know, I wouldn't have in the past. I still don't, really, because I don't see that book as being valuable to read.

However, five weeks after making that statement, I observed Diane do just what she indicated she would not think of doing. The fieldnotes from my observation of her non-UCSMP class in April 1993 contain the following:

They do not finish the lesson. She tells them that there are two other measures of central tendency called the median and the mode, gives them the page reference in their text, and asks them to read about the median and mode on their own. [Ask in the interview if she'd have done that last year.]

When I did ask about that in the follow-up interview, she told me: "I think I have done it in the past, but usually they don't do it. I would do it more frequently now, because of the UCSMP. Definitely."

Changing role in the classroom. Central to all of the other indicators of change in Diane's practice is a change in her role as teacher. My first observations of her practice left me with the impression that here was a teacher whose underlying philosophy of teaching was the transmission of knowledge through direct instruction. In this model her role was clear: She was the teller, the provider.

I watched that role change, sometimes subtly, as the school year progressed. Much evidence of this change has already been presented: the use of cooperative learning groups, the transition to taken-as-shared meanings, the development of mathematical connections, and the use of student reading as an instructional device in mathematics.

In March 1993, Diane told me how the reading component of UCSMP had pushed her to make other changes: changes in her planning, viewpoint, and role. I
seized the opportunity to ask just how she thought her role in the classroom had changed. She replied: "Now I'm more of a facilitator than a provider, I think."

Constraints to change. As much as the UCSMP implementation appeared to work as an agent of change in Diane's practice, it also provided two main areas of constraint. The first of these was a curriculum management problem. In March 1993, Diane told me:

The pace of the course is a huge constraint, I think. I think it's a constraint to the other aspect we were talking about before where I wanted to put more of my ideas into what I'm doing, and I think that part of me not being able to do that yet is because of the time constraint.

Apparently, though, Diane sees her experiences in the current year as opening up possibilities for the next. In her journal, she wrote: "My only complaint is that there isn't enough time. I want to have some slack, but don't feel there is any slack. I'm already looking forward to next year and time two through this course!"

The other constraint to change seemed to stem from Diane's lack of familiarity with the new UCSMP materials. In November 1992, I asked her to elaborate on recent journal reflections that indicated frustration and confusion on her part. With a chuckle, she replied: "I guess just like traveling down the unknown road is what it is mostly. And it feels like having less of a handle on the curriculum aspect for me makes the control, the management, more difficult."

Diane reiterated that theme in the April 1993 interview. After discussing some of the ways that she saw her practice change over the course of the year, I asked her if she felt that anything had constrained her from making such changes: "The constraint part I see as being mostly because it's new and I haven't done it before and that makes it a little more difficult to change."

An agent of constraint to change revisited. The areas in which it has been noted that Diane's implementation of the UCSMP materials seemed to foster change
during the first year of the study all seemed to have been areas of change during the second year as well. As might be expected, this was true to a greater extent for some things than for others.

It has previously been suggested that the development of mathematical connections in Diane's instruction continued into the second year of the study, albeit to a lesser degree than during the first year. Likewise, Diane continued her attempts to utilize cooperative learning strategies in the second year of the study, and she began using such strategies in her UCSMP classes. While this was something that I had not seen the previous year in the UCSMP classes, such uses tended to be pair activities that were limited to review contexts. Clearly, the use of cooperative learning strategies was still an area of change in Diane's practice, but I do not believe that it was to the extent that either of us expected.

The instructional use of reading remained a focal point in Diane's *Transition Mathematics* classes during the second year of the study. In fact, during my observation on 13 December 1993, I wrote: "I believe that this is the most "comfortable" that I have seen Diane with the reading aspect of the UCSMP text."

Later that day during the interview, while discussing her students adjustment to the expectation that they will read their mathematics textbook, she told me: "But I do find that they're catching on a lot quicker than last year, and I think that has to do with my experience. You know, in terms of finding the key ideas and doing the reading. I have been faster to let them do that on their own." She then acknowledged that she felt more comfortable with her students' reading.

However, Diane did not achieve the same degree of success in using reading as an instructional strategy in her *Transition Mathematics* classes during the second year of the study as she did during the first. The second year developed into more of a
roller coaster ride featuring peaks, where her students demonstrated some willingness to read independently, and vailesys, where any reading had to be done together in class. This probably led Diane to make the following observation in March 1994: "I still think reading is a worthwhile strategy. I really do; in my heart, I believe that. As far as getting the kids to do that, so that it is a worthwhile strategy for them, I don't know the way to do that yet." Nevertheless, she remained committed to finding that way: "I've tried lots of things, and I'll continue to try things!"

The great strides that Diane made in a transition toward the negotiation of taken-as-shared meanings with her students, particularly during the second year of the study, have already been described. This area of change, together with the instructional use of reading in mathematics that inheres in the UCSMP philosophy, perhaps underlie the remaining area of change that I have posited: Diane's role as the teacher is shifting away from one as the provider of knowledge and toward one as a facilitator of learning.

I continued to see evidence of such a changing role during the second year of the study. Two short paragraphs that I entered into my fieldnotes during my observations in February 1994 perhaps best capture the subtle nature of this transition.

I wrote the first of these following a class discussion of one of their homework problems: to find a solution to the equation \( x^y = 343 \). They had built a table for \( x, y, \) and \( x^y \), and they had generated 6 or 7 instances of this relationship. Diane abruptly brought the discussion to a close, and I noted:

What's interesting here is that she does not continue to a solution. Rather, she tells them that they now have an idea how to do it, and that they are capable of finishing themselves. She indicates that she expects them to continue to experiment and explore with instances until they find a solution.

I wrote the second entry to describe an incident that occurred during a whole-class discussion of a lesson that the students had read the previous night:
They are mostly engaged in the discussion, but when she asks a higher order question (Why do we generalize?), she gets no response. At that point, rather than just tell them, she speaks to them about giving the matter some attention, and then gets one student's idea. When no others are forthcoming, she says she is going to leave that one with them to think about for a while.

Eighteen months earlier, when Diane first began to implement *Transition Mathematics*, such teacher behavior would have been almost unthinkable.

In March 1994, near the end of the study, I asked Diane if my interpretation of a changing role as teacher remained valid. After a pause, she replied, with a sigh:

I think it still is a valid interpretation. I think there's still a lot of struggle for me in that. It's easier to tell them how it is. It takes less time. I get through what I need to cover. They prefer that I just tell them. Those kinds of things. However, I think they learn more when I don't do that.

Time constraints and the lack of familiarity with the new materials were the major inhibitors to change during the first year of the study. In the second year, the experience that Diane gained during the first year somewhat countermanded any lack of familiarity as a constraint to change. However, to a degree, familiarity apparently did remain an issue. In March 1994, in speaking about the UCSMP curriculum, Diane said: "It feels more familiar, but I still feel like it's somewhat of a constraint."

She then indicated that it will take more than just one year to gain a really comfortable familiarity with these materials.

Time, on the other hand, seems always to be a constraint to change. The first interview that I conducted with Diane during that second year was in December 1993. In response to my first question, in which I asked how the year was progressing in her *Transition Mathematics* classes, Diane said:

Overall, I feel more comfortable with it and I think that's my experience, having done it once. But still, many of the things we did last year and many of my feelings about there being a lot to do and about there being time pressure, they're still there.
In all of these ways, the innovative UCSMP materials acted to both facilitate and inhibit changes in Diane's instructional practice in both years of the study. Some of the areas in which change in Diane's practice was fostered by her implementation of the UCSMP materials showed lesser evidence of change in the second year of the study than in the first. Others showed greater evidence of change. Of the two inhibitors to change that were identified during the first year, only time remained a constraint during the second.
The Case of Gina

The 1993-94 school year was Gina's sixth year of teaching, all in the same
district. It was her fourth year in the school where she worked, which houses more
than 1,000 students in grades K-8. Many of these are ESL students, and this school
provides special services for such students. Gina indicated that over twenty different
languages are represented in the school's ESL program. It is the resulting ethnic
diversity which perhaps best characterizes the school.

The school is situated in a working class neighborhood of wood-frame homes
built very close to one another, even by urban standards. A strong sense of
crowdedness is almost inescapable. There has been a school on this site since the late
nineteenth century. The original building was replaced by the current structure in the
mid-1970s.

Although Gina was born, raised, and lives in the public school district where
she now works, she received her entire precollege education in parochial schools in a
neighborhood in a different part of the city from where she now works. She holds a
bachelor of arts degree with a major in mathematics from a small, private liberal arts
college located in a nearby city and is certified to teach secondary mathematics (grades
7-12). Currently, she is doing graduate work at a large state university, working
toward a master's degree in Teaching English to Speakers of Other Languages
(TESOL).

When I asked Gina why she decided to become a teacher, her response
indicated a long-term goal tempered by some immediate support for her decision:
"Well, I think I always wanted to be a teacher, but didn’t know what area, and I always had an affinity for math. And because, I guess, of being encouraged by some of my math teachers in high school, I pursued math in college."

While her undergraduate major was mathematics, Gina indicated a program that appears more liberal arts than technically oriented:

I ended up more interested in math as a liberal art and got into some of the philosophy of mathematics and things like that in college. It was sort of a different turn. I took calculus 1, 2, and 3, differential equations, linear algebra, foundations of math, number theory, and geometry. Non-Euclidean and Euclidean geometry; that was one of my favorites.

Certainly, these courses provide a broad set of experiences for a teacher of middle school mathematics. However, it is interesting that Gina’s undergraduate major in mathematics did not include the study of either abstract algebra or analysis.

Gina is one of two secondary certified mathematics teachers in her school. She teaches all of the seventh-grade mathematics, while her colleague teaches all of the eighth-grade mathematics. The eighth grade teacher began using the UCSMP Transition Mathematics materials in his classes during the previous school year. Gina is part of a pilot project which is investigating the feasibility of spreading the UCSMP Transition Mathematics and Algebra curricula over the course of three years (grades 7-9).

As I studied Gina’s first-time implementation of a UCSMP curriculum, I found a number of emergent themes that were reminiscent of my study of Diane:

- Gina is also a reflective practitioner.
- Gina is a structured teacher.
- The tension between procedural and conceptual understanding which I observed in Diane’s practice also revealed itself in Gina’s practice.
• Just as Diane appeared to begin a transition toward "taken-as-shared" meanings (Wood, Cobb, & Yackel, 1991), Gina seemed to begin shifting away from the teacher as a teller and giver of knowledge toward more negotiating of meaning with students.

• Mathematical connections began to take a more prominent role in Gina's instruction as the year progressed.

• As with Diane, the UCSMP text was both an agent of, and a constraint to changes in Gina's practice.

Once again, I will use these emergent themes to organize the rest of Gina's story.

**Reflective Practitioner**

Throughout my study of Gina's work, she gave ample evidence of a reflective practice in a myriad of ways. Two things that I learned about her background suggest that she has demonstrated reflectivity for some time.

During my first interview with Gina in September 1993, she told me that, over her first four years of teaching, she had improved her classroom management skills. She attributes this improvement to: "Taking different classes at the Teacher Center and talking to different people at inservices."

While I was not able to follow-up on that statement immediately, in October 1993, I asked her about the nature of those classes and inservices. She indicated that the content of them covered a diverse set of topics: cooperative learning, classroom management, whole language classes for ESL students, positive self-esteem, and learning styles, to name a few. This led to the following exchange:

**Interviewer:** So you take these mini-courses on a pretty regular basis.

**Gina:** I did, up until about a year ago. Then I started taking two graduate courses each semester. So that's what I did last fall, last spring, and am doing this fall, so it doesn't leave me any time for classes at the Teacher Center or with SETRC [Special Education Teacher's Resource Center]
offering Saturday inservices with a lot of the math inservices falling on
the same day. So actually in the last year, I haven't taken any. But
before that, I would take one or two, generally, a session.

I: Now in that last year, you've begun working on the master's degree. Is
that correct?

G: Yeah; those are the classes that I've been taking.

I believe that Gina's interest in professional development, taking advantage of a wide
range of inservice opportunities, and deciding to pursue a master's degree clearly imply
a reflective stance toward her work. This is particularly viable given her graduate
major in TESOL and the proportion of ESL students that she teaches every day.

The breadth of Gina's reflections spanned affective, as well as cognitive issues;
management, as well as instruction; and content, as well as pedagogy. We addressed
such issues in interviews, she wrote about them in her journals, and I noted evidence
of them in my observations of her work.

For example, the fieldnotes of my December 1993 observations of Gina's
classes contain the following entry:

She has the students preparing for an upcoming chapter test by working in
groups of 3 or 4 on a schematic diagram of the material in the current chapter.
She has given them enough information to provide them with an idea of what
their diagrams might look like, but at the same time, she has indicated that their
diagrams will be all different, and some ways in which they might differ.
While the kids work on this activity, and they do seem to be working with
some diligence on it, Gina walks from group to group, monitoring carefully
their efforts. Sometimes she does so without comment; at other times, she
asks questions to clarify things or suggest alternate directions.

When we discussed this activity during the interview that day, Gina called this a
"semantic map." I suspected, and she confirmed, that the source of this idea was her
graduate studies in TESOL. (For a description of semantic mapping, see Carrell,
Pharis, and Liberto, 1989, especially the examples that are illustrated on pp. 652-653.)
In March 1994, I asked Gina whether she saw any transfer from her TESOL studies to her day-to-day practice. I believe that her reply speaks to the reflective nature of her practice:

All of the time; all of the time. Anything that a teacher would do in an ESL class is going to catch any other student that would normally fall through the cracks; if certain techniques or methods weren't used. The whole idea of presenting things visually, going over certain words, emphasizing terms, giving them sort of this background knowledge that you might assume native speakers have, but sometimes they just don't. I don't think there's one TESOL method that doesn't help other students. I think it definitely helps. I think I'm a better math teacher, having had the ESL experience.

The depth of Gina's reflections can be seen in her concern regarding possible affective changes for her ESL students that might arise due to the reading requirement inherent with the UCSMP materials. In a journal entry in late September 1993, three weeks into the school year, Gina wrote:

I'm concerned about reading, especially considering the language problems of the many ESL students. I always felt good about the way ESL students could succeed and excel in mathematics. To me, it was an important part of their day to feel that success. Now, it doesn't seem it will come so readily.

As in this example, Gina's reflective activity was often in direct response to UCSMP. Many times it involved making instructional decisions that were tempered by the UCSMP materials. In the semantic mapping activity discussed earlier, she tailored a reading activity from her TESOL graduate studies to fit her mathematics instruction.

Interestingly, just as Diane had, Gina found the use of cooperative learning groups a promising venue in regard to teaching with the UCSMP materials. However, Gina came to this conclusion quite early in the year and found it inescapable. In our very first interview, I asked her how importantly she viewed cooperative learning groups as an instructional strategy. She replied, "In the past I haven't used it,
definitely not most of the time, and probably not half of the time. I don't think I'm going to have much of a choice with this program."

Finally, the one interpretation that I made regarding Diane's practice that I could not make with regard to Gina's practice is a predisposition to change. In making that interpretation with respect to Diane, I viewed her disposition to change as something of a subconscious force. It often seemed that she had been perturbed, had encountered some tension or dissonance in her practice of teaching, but had not yet articulated that perturbation to the point of forging some definite commitment to change. On the other hand, whenever Gina made instructional decisions, whether they implied a change in practice or not, I had the sense that she was choosing a well-considered course of action. It never occurred to me that she made such choices due to any such predisposition, but rather that she did so after careful reflection in reaction to specific contexts.

For example, with respect to her decision to use cooperative learning groups, Gina told me: "I'm just going to have to have them work in groups, just to get as much experience as possible ... because of the pace of the course; because of the whole setup of everything." In this instance, Gina saw the implementation of a UCSMP curriculum, with its heavy reliance on student reading, as problematic due to the large number of ESL students in her classes. She then decided to use cooperative learning groups, which provide a format for students to utilize each other as resources, as a response to the problematic situation with which she was faced.

It was clear to me that the driving force in the forgoing vignette was Gina's reflection. On the basis of incidents such as this one, I made my interpretation of Gina's practice as reflective without reservation.
Structured Teacher

The first thing that I noticed about Gina’s work in the classroom was the lack of any wasted time. Such a notation appears in the fieldnotes for my first observation of Gina’s teaching in April 1993, and reappears in the fieldnotes of my next visit with her in September 1993. While one could argue that making efficient use of the classtime is a necessary, but not sufficient condition for a structured teacher, my sense of Gina’s practice is that it is precisely that structure; her routines, her sense of order, her sequencing of the lesson, and her sense of the temporal arrangement of the lesson; that allows her to use the classtime efficiently.

The importance of routines in Gina’s thinking was apparent in her description of differences in her teaching last year, compared with her first year of teaching. She described a major difference in these terms:

I think what I did last year was sort of establish some classroom routines more; like bellwork is always in the same place, that’s the first thing you do, homework assignments - not spending a lot of time going over things like that, you know, having answers listed on the board or on the overhead for kids for them to go over instead of wasting a lot of class time. I think my management improved somewhat over those four years.

The importance of those routines was further confirmed by the frustration that she felt when her use of the UCSMP materials initially upset some of those routines. Reading an October 1993 journal entry, it is easy to sense her relief at being able to write: "I feel like I’m adjusting my routines."

Gina’s responses to a pair of questions that I posed in our first interview in September 1993 add to the viability of this interpretation. When I asked how she plans her instruction, she said: "I usually have long-term plans where I know exactly what I want to cover and how I’m going to do it." Then, when I asked what she saw as characteristics of a good math teacher, she replied at once: "Organized!"
Small wonder that I had written in the fieldnotes of my baseline visit to her classroom that: "Gina's half of the room shows a good deal of organization. She has bellwork and homework prominently posted on the chalkboard, in predetermined, labeled places. In addition, she has an "agenda" posted, giving a synopsis of the week's work."

In a later interview, I asked Gina if she believed that my interpretation that she is a fairly structured teacher was accurate. Her response confirms the interpretation:

It's accurate. I like structure, and I think a lot of it is my personality. And it's also 7th graders. They desperately need the structure, and I think that shows, with the routines I want them to be in when they come in, with the things I expect them to have with them, the way we just sort of proceed through different things throughout the classtime. I think that's very accurate.

**Tension Between Concepts and Procedures**

The tension in Gina's practice between her concern for students' conceptual as well as procedural understanding began to reveal itself during my initial observation of her work in April 1993. My fieldnotes from that visit resemble a pendulum swinging between these two extremes. A typical example is the following entry, which describes a single interaction between Gina and one of her students: "They talk about rounding - she reminds them about aspects of the procedure. When a student has a mistake in rounding to the nearest 10,000, she asks, 'Is it closer to 80,000 or 90,000?' trying to establish a conceptual link." And so the emphasis shifted back and forth between concepts and procedures for the duration of that first visit.

I must acknowledge the fact that when I visited Gina in April 1993, I had already discussed with Diane a similar interpretation that I had made regarding her practice. It is entirely possible that what I had observed and interpreted about Diane's practice colored my observations of Gina's teaching. However, I continued to see evidence of this tension between concepts and procedures in one form or another.
during most of my subsequent observations. On the one hand, Gina attended to
transitions between various representations of a concept; on the other hand her
attention was directed toward rules. Sometimes she was more interested in students'
explanations of their work than in small errors that were of little consequence. Other
times her explanations were focused on the correct procedure only. Her use of
concrete examples as a means of establishing a conceptual basis upon which her
students might build understanding was often juxtaposed with totally rule-bound
explanations of mathematical procedures.

I engaged Gina in the following dialogue during the interview in October 1993.
I believe that it demonstrates some ambivalence, as well as a tension, between
conceptual and procedural knowledge:

G: [Sometimes] you really don't have to understand what's happening, but
just do this and you'll get to the answer. I still think they have to know
what's behind it. It's not just the procedures or the little things you do,
it's what's behind all of them that I think they have to be aware of.

I: So there's kind of a little tension going on there between the concepts and
the procedures.

G: Oh, yeah! Yeah, I think so. I would say, yes, there is tension. Because
I feel it's something they need to know; and they have to be provided
with it, but they might not get it right away. They might not get it by the
test; they might not even get it by the time the exam rolls around, but
eventually they might remember ... you know, a couple of years down
the road.

Although I noted evidence of such a tension months before Gina began to use
the UCSMP materials, she ascribes a significant role to UCSMP in the development of
that tension. Gina had written in an early journal entry that "Transition Mathematics is
very different from what we've experienced before." Then during the October 1993
interview I asked her to elaborate on that difference. She replied:

I have to figure out ways for them to see math in a lot of different areas that
maybe I didn't take the time to do before. I was concerned more with
procedures rather than with all the concepts in the past, and I think that's what
the students have kind of been taught to work with, too, rather than making it real for them in any way. I think with the Transition Mathematics there's no choice but to make it real, because that's what they have to work with. They have to be able to reason through the problem, they have to understand the problems, they have to be able to reword them, explain to you what's being asked, and I have to elicit all of that. So I think it's different for both me, as the teacher, and the students.

In March 1994, I asked Gina specifically if she felt more, less, or about the same tension between procedural and conceptual learning as in the past. Her response suggests that there had been a shift in her focus:

I think maybe less. I think my teaching is more conceptual this year than it has been. And I think it goes back to the students working through things on their own or in groups. I think they've learned that it's up to them, in a way, to connect the concepts to each individual problem, and sort of make up the procedure from there. Rather than rely on the same procedures to do other problems.

Although I have suggested that the concepts/procedures tension was evident in Gina's instruction before she began teaching Transition Mathematics, the foregoing suggests that this tension was exacerbated by her UCSMP implementation. Moreover, the implication is clearly that the style of the UCSMP materials themselves might well serve as a catalyst as the focus of instruction shifts from procedural to conceptual aspects.

Towards the Negotiation of Meaning

During my baseline observation of Gina in April 1993, it became clear to me that, while Gina was a patient, understanding teacher who was accepting of students alternate ways of doing things, she also regarded the teacher as the final authority for mathematical results. This interpretation was based upon her habit of always acknowledging student responses as, "Correct," when they were, or of always providing some clue, such as a voice inflection, when an error had been made. Moreover, during a class discussion in which she asked for the meaning of the word "miscellaneous" and received an acceptable, if not perfectly clear, student response, she
ended any possibility of a negotiated meaning by providing all of the examples herself. Toward the end of that baseline observation, I wrote in my fieldnotes that "she clearly is the judge of correctness."

I noted similar tendencies during my early observations of her uses of the UCSMP materials the following school year. Particularly during reviews of homework assignments, it was obvious that the teacher was the authority for correctness. The fieldnotes of my September 1993 visit contain the observation that "she is the mathematics authority in the room." I also noticed that most, if not all, of the examples that were used in the lessons that I saw in September and October 1993 were provided by the teacher or by the textbook. But I also noticed the seeds of change.

During my observation of a Transition Mathematics class in September 1993 (she had only been using the UCSMP textbook for about two weeks at this point), I watched Gina use a negotiation process to settle a difference of opinion that her students reached regarding the comparison of -1 and -1.5. It might have been easier to just tell them, and it certainly would have been faster, but Gina took the time to let students express their understandings of inequality and negative numbers. In this way, they were able to resolve this discrepancy themselves.

Later during that same class, she had her students write: "Three numbers can be compared in the same sentence if they are in order." Then she asked, "What do you think I mean by the word 'sentence'," and, "What does 'in order' mean?" Finally, the students were asked to generate examples such as 1 < 2 < 3. Each time, Gina asked, "How does everyone feel about that answer? Do you agree with it?" This was a radical departure from anything she had done during my observation the previous April, or even earlier during that same class period.
Further evidence of this transition toward a process of negotiation of meaning with students can be found in an incident that I observed in one of Gina's classes in January 1994. During the lesson that day, Gina attempted to help her students come to the realization that the calculator, while an efficient tool when used sensibly, can actually become a hindrance when used thoughtlessly. Throughout the lesson, it was easy to sense a spirit of negotiation in her words. My fieldnotes contain this description:

They are evaluating $3+5(2+5(1+5))$. As she writes this down, she asks, "Have I got that right?" Then she asks if the numbers will be hard to work with. They agree that they aren't.

Next, she asks them to write down this problem: $8/(8/(2+6))$ and solve it. She asks, "Are any of these numbers complicated? Are the operations complicated?" They agree that they are not complicated; that it involves just an addition and two divisions.

Then she asks them to work on $12+7(3-(5-4))+17$ using the calculator, having previously done it "by hand". They get all sorts of things; she has two who got two different wrong answers, "put your heads together to see if you can figure out what's going on." She asks, "What's happening here?"

They tell her that people are getting different answers and that means they are doing it differently. She does it on the overhead calculator, telling them that there is a lot to remember, and that they'll have to watch her in case she makes a mistake.

They consider the example $2(3+14(14+1)+5)$. Before they do so, they write out the key sequence. One of the students says, "Boy, that's a lot!" She then, without agreeing or disagreeing, asks if there was a lot of work in doing the problem by hand in the first place. They agree that there was not.

She ends the class by having them summarize what they learned today. One of the students provides that summary.

Fullan (1982) observes that effective change takes time. Perhaps this is so in the case of instructional practice, because teachers need the time to assimilate the new strategies that they are attempting to employ. Perhaps it is nothing more than old habits that are slow to die. At any rate, Gina's first steps toward the negotiation of meaning with her students did not signal a complete make-over in her style of teaching. They were merely first steps.
Throughout my observations of Gina's teaching, I witnessed an ambivalence similar to that which had surfaced in Diane's practice the preceding year. At times she instigated a process of negotiation with her students, yet at other times she simply functioned as a "teller," or provider, of knowledge. Often, this occurred during the same class period; sometimes it occurred within the same activity.

For example, in November 1993, Gina discussed with one of her classes the solution to the question, "Find 0% of $17.50." My fieldnotes contain this description of that exchange:

Gina asks if the answer zero makes sense. They agree that it does, but it is Gina who provides the explanation of why that makes sense. She extends the problem by asking them what 50% of $17.50 is. She gets one way to do it; then asks if anyone knows another way. When there is not immediate response, she points them in the direction she wants by asking, "What is 50% really equal to?"

Thus it can be seen, within one tiny portion of one class period, that, on the one hand Gina attempted to negotiate meaning through sense-making agreements and alternate methods of solution, while at the same time imposing her own meaning by providing the explanation and leading her students in the direction that she wanted to take.

But Gina had an awareness of this transition and sometimes consciously took steps in the direction of a shared authority. In March 1994, she described a typical recent event that occurred during a problem solving unit:

I really emphasized alternate ways of working problems out in the problem solving unit. For any one problem, we might have had three different demonstrations and I'd say, "There's no point in me doing it. I'm sure everyone understands this stuff, because you did it, rather than me getting up and showing you my way of doing it." So we did that sometimes.

When I reflected on Gina's nature as a teacher when I first observed her work some eleven months prior to this interview, such a statement would have seemed unthinkable.
Mathematical Connections as a Focus of Instruction

In discussing mathematical connections, I include connections between mathematics and students' everyday lives, connections between mathematics and other academic areas, connections between mathematics and students' prior knowledge, and connections between mathematical concepts themselves. While in my baseline observation I did not observe any particular attempt by Gina to help her students form mathematical connections, I did observe some movement in this direction as my observations of her practice continued through the 1993-94 school year.

The first reference to mathematical connections that I made in my fieldnotes occurred during my observation of Gina's teaching in October 1993. In that reference, I simply noted that: "Gina interjects questions in an attempt to point out important parts of the lesson they are reading together. She is clearly attempting to get them to connect the key ideas in the lesson."

On my next visit in November 1993, I noted that: "The focus today seems to be on why standardization of units of measurement is necessary. Gina is connecting the development of measurement with parallel historical developments."

I placed a memo in my fieldnotes at this point to ask Gina during the interview if she had attempted to make such connections in the past. She told me: "No, I hadn't done it really with measurement before. Geometry is where I used to make, more, the historical connections. No, in the past I guess I didn't." Then when I asked if I was correct in inferring that the textbook had been the source of the historical connections that I had seen that day, she replied: "Oh yeah! Definitely!"

Two journal entries that Gina made in December 1993 shed more light on this issue. In particular, they suggest that Gina herself views the UCSMP materials as an
important catalyst in the increased emphasis on mathematical connections in her
instructional practice. Early in the month, she wrote:

I find some of the [textbook] examples (and "Additional Suggestions" in the
Teacher's Edition) very interesting. I think this changes how students respond
to questions, examples, or introductory activities for some topics. I notice
some students seem more comfortable offering comments. They seem so
satisfied with themselves to recall an advertisement or something they saw on
TV or some athletic statistics - anything remotely connected to what we are
learning about.

Later in the month, she reflected on a change that she perceived in her work:

The students' level of participation changes how I do some things. I spend
more time with introductory discussions. I see the value in just getting them to
talk about math, look at it differently, and make even the most remote
connections to their lives and their present knowledge.

An Agent of Constraint to Change

I have previously argued that the innovative UCSMP materials acted to both
foster and inhibit changes in Diane's instructional practices. As I followed Gina's
implementation of the UCSMP materials, I was struck by strength of the similarities in
this regard between the two cases. Not only did I also see Transition Mathematics as
both an agent and a constraint for change in Gina's practice, but specific ways in which
these two aspects revealed themselves in Gina's work were often along the same or
very similar lines to those that I had observed in the case of Diane.

The UCSMP implementation appeared to have facilitated changes in Gina's
practice in six areas:

- the use of cooperative learning strategies,
- a transition toward the negotiation of shared meanings,
- an increasing prominence for mathematical connections,
- the use of student reading as an instructional strategy,
- the use of student projects as learning devices, and
- a changing role for the teacher herself.
At the same time, factors related to the UCSMP implementation which appeared to inhibit change were:

- time constraints, and
- the lack of familiarity with the new materials.

The use of cooperative learning strategies. Gina's early interest in using cooperative learning groups in conjunction with her implementation of the UCSMP materials was noted earlier in arguing for the reflective nature of her practice. She first expressed that interest in September 1993 during the interview.

On 9 October 1993, she wrote in her journal: "I rearranged the room so they are in groups of four - will spend time next week getting used to rules and expectations for this arrangement and cooperative activities." Two weeks later, she wrote: "The group work has been going okay. I've given group assignments on some textbook problems that were the previous night's homework. They also must answer selected problems on a handout using only the textbook and each other as sources."

Then, in early December 1993, she made the following entry:
For reading comprehension:

1. I had students in groups read and then complete the notes for the lesson. I had given them an outline of what needed to be included for the lesson.

2. I also want to try some semantic mapping exercises with them. This is what I have in mind: brainstorm together using the word "measurement," in groups, categorize and organize the information. Then map it and evaluate.

Clearly, this is the semantic mapping activity, which I observed on 14 December 1993, and which was previously described in the section that discussed Gina as a reflective practitioner.

I also observed Gina use group activities in classes during my visits in October and November 1993. Thus, I was really quite surprised to read this next journal entry, dated 30 December 1993:
For my own sanity, I went back to desks in rows for the week before Christmas. I think I'll try another arrangement after the holidays. Maybe a horseshoe. I'm finding groups of 2 or 3 more productive than 4. I want to try dividing some activities into two phases - where they will work in pairs first and then join another pair.

In response to this entry, I wrote back, asking if she was familiar with the Think-Pair-Share technique of cooperative learning. (See Davidson, 1990, pp. 60-61 for a description of this cooperative learning strategy.) In her next journal, written in mid-January 1994, she wrote:

I have encountered the Think-Pair-Share technique in some cooperative learning workshops. I've used it somewhat in the honors class. I like it because it doesn't involve any special arrangements and can be used for very simple or more complex tasks.

When I visited in January 1994, the desks were indeed arranged in a horseshoe. The seating arrangement remained the same throughout the balance of the school year. In February and March 1994, I observed Gina using small group activities to review material in preparation for impending chapter tests. True to her earlier reflection, the students worked in pairs or groups of three.

During the interview on 11 March 1994, I asked Gina to tell me about any changes she might have made that she saw as derivative of her use of the UCSMP materials. Without hesitation, at the top of her list was: "I've done more group work."

The negotiation of shared meanings. Gina's transition toward the negotiation of shared meanings with students was described in detail in a previous section. She was well aware of the transition. In January 1994, I described to Gina my interpretation of a movement in her practice toward the negotiation of meaning with her students, and I asked if she believed that my interpretation was accurate. She replied:

I think so; that's what I've been trying to do. I know there were things I had to change, and things that I try to do to facilitate that whole feeling that it's a community and that I am the facilitator, rather than the lecturer up there providing all of the knowledge. So ...; yeah, that's something I try to do.
She saw sources of this development other than UCSMP: "It hasn't been just because of the *Transition Math*, but because of all the other things: trying the cooperative learning and learning styles and letting them work things out in different ways and try things by themselves."

However, when I asked her in February 1994 what the source of her interest in "all the other things" had been, she told me that she saw a connection with her involvement in the UCSMP implementation. She provided this example:

I think for so long I took some of the cooperative learning inservices and I was going through all that, but not doing much with it. It just seems that this *Transition Math* lends itself very well to a situation like that. If for no other reason than I can't do it all by myself. I could never get through all of the questions. I could never do it. So I think in a way I'm just forced to use it.

*Mathematical connections.* I have also previously described the increasing prominence of mathematical connections that I observed in Gina's classroom as her UCSMP implementation progressed. We addressed this issue of mathematical connections in the December 1993 and January 1994 interviews. In December, I quoted something Gina had written in an earlier journal, that the *Transition Mathematics* text was "more real and relevant," and I asked her if that changed things in her classroom in any way. She replied:

I think so! I think the discussions, they kind of take a different turn. I'm not sure where the discussions are going to go, a lot. But I always find it interesting, when they tell me something that I've never even thought of, or they make some sort of connection.

Then in January, after Gina told me that her students were doing more mathematical connecting than in the past, I asked her directly how that changed the way she does things. She said:

I think it goes back to sort of letting the students discover things on their own. Sort of letting them make some of these connections and letting them come up with the examples in situations and making the connections, whether it's to the outside world or whatever. And I think that's just part of the program. Just
sort of bringing the ownership of all of this, all of the *Transition Mathematics*, right to the students, and letting them explore and discover.

In describing the effects of her students' budding ability to draw mathematical connections in this way, Gina seems to tell us that this development underlies some significant and worthwhile changes in her practice. In particular, the statement regarding ownership seems to imply a clear connection between these effects and the concurrent transition toward the negotiation of meaning with her students.

*Reading as an instructional strategy.* Gina recognized early in the year that the large number of ESL students in her classes might become problematic as she implemented the UCSMP materials. On 24 September 1993, she wrote in her journal: "I'm concerned about reading, especially considering the language problems of the many ESL students."

Later in that same journal entry, she wrote: "I've used some suggestions to focus more on reading skills with everyone - skimming, finding important words, strategies for answering questions. I know I have to continue stressing these reading strategies in class."

In November 1993, again writing in her journal, she considered the extra "flexibility" that she had as a result of her pilot implementation of only the first 7 chapters of the *Transition Mathematics* textbook: "I feel the additional time I have goes toward reading. I'm still covering the reading orally in class and really have no plans to change this."

During the interview in December 1993, Gina told me of a recent discussion she had with her classes: "We talked about how it's different that they have to read. They were never given those reading assignments before." Clearly, this statement acknowledged that just the process of student reading was a change in instructional format.
However, there was more than mere form to this aspect of change. It is important that Gina's implementation of reading strategies also changed her classroom in substantive ways. A journal entry from November 1993 sheds light on the substance of these reading-related changes: "We are spending more time discussing reading also. Their comprehension doesn't seem adequate, so I realized I have to interject my own comments and elicit theirs several times during the reading [emphasis added]."

Hence a problem with students' reading comprehension was addressed through class discussions in a manner that incorporated the exchange of ideas between teacher and students. Such an interpretation also fits well with the notion of a transition to the negotiation of meaning with students.

**Student projects.** The monthly Saturday morning UCSMP inservice meetings conducted by the district's Director of Mathematics have previously been mentioned as a possible source of peer interaction and support for the teachers who were implementing the UCSMP materials. Having been one of the original three pilot teachers for UCSMP in this district, I was well aware of the nature of those meetings when they were begun during the 1990-91 school year. Because I was curious to learn if those inservice meetings were substantially the same in 1993-94, I attended one such meeting on 16 October 1993. I found the format of this meeting to be remarkably similar to the earlier ones: teachers presenting instructional ideas to other teachers.

It had been decided by the UCSMP teachers at the September inservice meeting that student projects would be a required part of the district-wide final assessments in each of the UCSMP courses. Therefore, the central theme of this meeting in October was student projects. Six different teachers presented various projects that they had successfully used with students at grade levels ranging from grade 7 through grade 12.
Gina was in attendance at that meeting, and she apparently took the presentations on student projects to heart. One week later, she wrote in her journal:

I assigned a project on Thursday, the 21st, to be turned in on Friday, the 29th. It's a "Scavenger Hunt" using newspapers and magazines. Students need to cut out examples of certain ideas (an estimate larger than one million, a range of values, numbers written in order, etc.), label each, and display on a poster or in a booklet.

When I visited Gina in early November of that year, I noticed that she had perhaps two dozen of these student projects displayed in her room. She was somewhat sheepish when I asked her about them, indicating that she was disappointed in their accuracy. Moreover, she believed that many of them demonstrated students' misconceptions regarding the mathematical concepts that the project addressed. Nevertheless, she was upbeat in her assessment of the project and told me:

I decided to find something positive in it, and the fact is that they went through newspapers, and they looked for examples, and they went through magazines, and they cut things out, and they arranged them. I think it got them used to the idea of having projects in math, of looking for evidence of math in newspapers and magazines.

Gina considered this project to be a qualified success (there were those inaccuracies, after all) and indicated that she planned to use future projects.

A month later, when I visited in December 1993, Gina was planning another project. This one concerned the nature of mathematics among diverse cultures, involved some library research, and incorporated a group structure. Ultimately, Gina utilized this project in the early spring. When I asked her if she had used student projects as a learning device in prior years, she replied: "No, I haven't. I think I might have had them do biographies one year, but I haven't had them do projects like this."

Changing role of the teacher: From source to resource. My interpretation that the changes Gina made in her instructional practice during her first year of a UCSMP implementation fostered a shift in her role as teacher follows naturally from the nature
of those changes. Her movement toward the use of cooperative group work necessarily implies such a shift, as does her transition toward the negotiation of shared meanings with students. Both of these changes tend to restructure learning environments as more student-centered. Both cast the teacher in more of a facilitator's role.

The emergent prominence of mathematical connections in Gina's instruction and the way she approached her students' problems with reading both demonstrated the sort of free exchange of ideas that is often associated with the "teacher-as-facilitator" model of instruction. Over the course of the 1993-94 school year, I watched as Gina became less concerned with her routines and procedures and more concerned with developing greater flexibility in the classroom. As she phrased it in a journal entry, "I think I'm searching for my comfort level with this."

In February 1994, Gina continued to address this issue of a possible role-shift in her journal:

I do see my role changing this year. In the past I considered myself as the "source" that would demonstrate and model strategies, then give guidance as students practiced things on their own. But now this year, with Transition Mathematics I've been re-thinking all of that. I see myself as more of a facilitator and a "resource." My role is to give students the chance to do some exploring and discovering.

Later in that same journal entry, she made a comment that would have been almost heretical the previous spring: "I like taking the chance to tell students they make better teachers than me very often - that they can explain concepts more clearly to their classmates than I can."

She ended that journal entry with these words: "I sense myself getting students to think about math in a new way." Just as I, in a similar vein, sense that she is beginning to think about teaching mathematics in a "new way."
**Time constraints.** Almost from the beginning of the school year, Gina provided evidence that she often felt constrained by time as a direct result of the UCSMP implementation. In her very first journal, she wrote: "I often feel rushed to complete as many of the problems in class for each lesson." It was easy for me to sense this feeling as I observed Gina's work. My fieldnotes from observations on 14 December 1993 provide a typical example:

I can clearly see some attempt to engage students in what I would call a negotiation process, but I also detect a sense of "hurriedness." In one case, she asks for an alternative response, but when what she gets is not quite what she was looking for, she hurriedly explains what that students' thinking had been, rather than asking the student to do that himself.

The issue of time also arose frequently and spontaneously in my interviews of Gina. In December 1993, the following exchange occurred in the interview:

**Interviewer:** Does the fact that *Transition Mathematics* is more relevant and real to them change things in your classroom in any way?

**Gina:** I think so! I think just with they discussions, they kind of take different ... I'm not sure where the discussions are going to go, a lot.

**I:** Is that a good thing?

**G:** Yeah! I don't mind that. Although, I probably did mention this, I'm always worried about the time, and the clock, and, you know, things can't get too far off-track.

Later, while we discussed the semantic mapping activity that has been previously described, she said simply, almost in exasperation: "We need more time!"

In a journal entry dated 30 December 1993, she continued this theme when she wrote: "I just do not allot enough time in a given class for some activities" [original underlined]." Finally, in January 1994, she told me: "I have to figure out how to focus time more."

I interpreted this sequence as a struggle to fit change in practice into a context that was charged with pressure to complete a given amount of material within a certain
time frame. Gina was determined to make changes, but felt she had to reconcile any such change with the time she felt was available. Moreover, as her own words convey, it can be difficult to institute change while looking over one's shoulder at the clock.

_Lack of familiarity as a constraint._ Gina herself raised the issue of her lack of familiarity with the _Transition Mathematics_ textbook as a constraint to change. It appeared to be closely related to the time constraint discussed above. In October 1993, while we were discussing time as a constraining feature, she complained that "I would say there's a time constraint; I'm watching the clock constantly."

I acknowledged her remarks and asked if her clock-watching was new. She replied:

Yes! Because, I guess because after five years of teaching the same stuff, I kind of knew what they were going to have problems with. I kind of knew which questions would give them a problem. But I really think it's just not having been through it before.

Thus with Gina, as with Diane, there seemed to be an uncertainty about "the unknown road" not previously traveled that acted as a constraint to change.
The Case of Kathy

Kathy teaches in a high school of approximately 800 students. The 1993-94 school year was her third at this school, and she has a total of four and one-half years of teaching experience, all in this district.

The school is one of the oldest in the district, the building itself dating from around the turn of the century. Although the building is fairly well-maintained, the rooms are quite small by today's standards. The building is situated in the same neighborhood as Gina's school; perhaps but a five minute walk separates the two.

The school has a reputation in this district as being well-run by a capable building principal. The discipline problems that plague many urban high schools have not been a factor here during this principal's tenure, a period of some eighteen years. From what I could see during my visits, the school's reputation for good-order continues to be deserved: students changed classes in an orderly fashion, I observed no students loitering in the corridors during classes, and I did not notice any particular discipline problems in Kathy's homeroom or either of the two classes that I regularly observed. The student population in Kathy's classes was ethnically mixed, with about 50% minority students. Most of the minority students are African-American; perhaps one-third are Hispanic. A still smaller proportion are of Asian ancestry.

Kathy grew up and attended elementary and high school in a small rural community approximately 75 miles from the city in which she now works. She received bachelor's and master's degrees in mathematics from a small state college with a strong history and tradition of teacher preparation.
Kathy has attended workshops during the last three summers. In fact, she attended two different workshops during the summer that immediately preceded my study of her UCSMP implementation. These seemed to have sparked two areas of interest for Kathy: the instructional use of calculators and computers in mathematics and the use of real-life applications in the teaching of mathematics. There is one more thing that underlies much of what Kathy does in the classroom: her desire to make learning fun for her students. In fact, this is apparent in her description of the teacher who inspired her to become a teacher, and in a comparison of herself to that person: "Well she just ... she made it so that you wanted to get yourself to learn, and it kind of made math fun. Which is what I try to do. I try to be ... I don't want to be one of those boring teachers ... I want to put some fun into it."

Kathy seems to have reflected on this matter: "I believe that kids learn better when you make it fun. I think if you make it fun and interesting for them, they tend to cooperate more." However, her quest for making mathematics fun for her students seemed to manifest itself mainly in the use of classroom games as review activities: "I like to play games. In the past, I've always done "Bingo Days," which is a spiraling review." In fact, all of her descriptions of making learning mathematics fun for students involved such uses of games (Jeopardy and Family Feud were others) as vehicles for review.

During the year that I studied Kathy's UCSMP implementation, her teaching load consisted of three UCSMP Algebra classes and two classes that did not use UCSMP materials. The students in Kathy's Algebra classes came from all grade levels from 9-12. About one-half were 9th grade students who had studied the UCSMP Transition Mathematics course the previous year. On several occasions, Kathy told me that many of her 11th and 12th grade students had already satisfied their
district's rather meager mathematics requirement for graduation from high school. This apparently led many of these students to hold an attitude that they did not really "need" the Algebra course that they were studying.

Kathy favors what I would term a direct instruction model in her teaching style. I made such notations in my fieldnotes beginning with my first observations of her work, which occurred in September 1993. A note from my visit in December 1993 is fairly representative: "She tries to get her students to relate what they are learning to a real life situation, but she provides almost all of the information. I cannot help noticing who is doing most of the talking: it is Kathy [perhaps 75-80%]."

Kathy's teaching resembled the work of a skilled technician. Her fast-paced lessons were characterized by vivid explanations of mathematics procedures and concepts, with a good deal of active student involvement. The fieldnotes of my visit in February 1994 contain the following summary of a typical lesson, which was written at its conclusion:

The period is over, and I must say that it flew by. There was no wasted time, to be sure, and the students were mostly engaged and on task. There was a lot of direct instruction, and she used many mnemonic devices and other memory aids to help them remember what to do.

Despite the pace, I noted that: "Many students appear to be right with her."

Kathy is determined to teach her students the mathematics she believes they will need to know in the future, and she is confident in her ability to do so. In our first interview, on 20 September 1993, she stated: "I've always been confident. I grew up in a small town and no guy could ever tell me, 'You're a girl; you can't do that.' I'd always have to show them that I could. And so, as far as I'm concerned, there's nothing I can't do."

Kathy does what she does with the best interests of her students always in mind. A good example of this was imbedded in her approach to the difficulties her
students encountered with reading the UCSMP Algebra text. Early in the year, Kathy experimented with reading the text in class. By the end of October 1993, she had changed her thinking on this. In a journal entry, she wrote: "It would be better if I explained the material so that they get an idea of what is expected." Then during the interview in November 1993, she provided a rationale for shifting the reading from a whole-class activity to an independent student responsibility: "When we're reading in class, I'm not explaining anything to them. It's just words to them. They have [the question], 'What does it mean?' And we weren't getting to that: 'These words mean this!'; That's why I feel better." The motivation for Kathy's action in this regard seems clear from her statement, "It would be better if ...." Kathy's students sense her interest in their success, which helps her to maintain the comfortable rapport with her classes that was always apparent when I visited.

Kathy's UCSMP implementation during the 1993-94 school year demonstrated a number of similarities and differences when compared with the cases of Diane and Gina. Kathy's case was similar to the other two in the constraints to change that she encountered:

- time management and
- a lack of familiarity with the textbook and materials that she was using for the first time.

There were also some important differences:

- Kathy's practice of teaching changed in ways that were different from the changes that I observed in Diane's and Gina's practices,
- Kathy focused on the procedural aspects of the material in the UCSMP textbook, and
it appeared that Kathy adapted, rather than adopted, the innovative materials.

*Constraints to Change*

From the beginning, I sensed that Kathy often felt pressed for time. This remained a source of frustration for her throughout the year. Compounding the issue of time management was her unfamiliarity with the innovative new instructional materials that she was using for the first time. Both of these same issues were encountered with the other two teachers also.

*Time management.* Kathy confirmed my interpretation that she often felt rushed during our first interview in September 1993. Then, near the end of October 1993, she wrote in her journal that: "There is frustration because there is so much to cover, and by the time I go over the homework, there isn't much time to work on the next lesson." Later in that journal entry, the same theme surfaced in her account of the difficulties her students were encountering, "because there isn't enough time to go over the homework and read the next lesson in its entirety and students just do not finish the reading on their own.”

My fieldnotes also contain frequent references to her being rushed or hurried. Clearly, time management was as significant a constraint on Kathy as it was on Diane and Gina.

*Unfamiliarity with the UCSMP materials.* Kathy's unfamiliarity with the UCSMP materials was also as large a constraint to her ability to make desired changes as it was for the others. Kathy first mentioned this in an informal discussion during my visit in December 1993. My fieldnotes contain this account:

Kathy indicated during informal conversation that she believes that next year, she will be able to include a much greater use of technology in her *Algebra* classes than she is able to this year, due to her unfamiliarity with the new curriculum and materials this year. She also said that she expects to be better
able to utilize the technology next year, when she has gained some familiarity with the new materials. I then asked her directly, "Do you feel constrained by the newness of the materials this year?" She answered, "Yes!"

Later that day during the interview, she told me: "In future years, I'll have an idea of what they're [her students] going to think. Then I'll know how to handle it and be able to put something else in with it. *I think the first year of teaching anything is hard* [emphasis added]." Finally, in February 1994, Kathy elaborated further:

I have a feeling that this year I'm not going to get in as much technology as I'd like to, because it's the first year through it and I want to know where my trouble spots are and where they're not. But I have a feeling that next year, I'll be able to implement a lot more technology when I have a better feel of what I want to do.

Without question, Kathy felt constrained by the lack of time and familiarity with the UCSMP materials, particularly as she searched for the means to incorporate technology in her mathematics teaching.

*Different Sorts of Change*

Of the three cases, during Kathy's initial year of implementing a UCSMP curriculum, her practice changed in ways that are the most dissimilar to the others. Moreover, her most prominent changes did not seem to derive from her use of the UCSMP materials alone. The changes that did occur - the use of technology in instruction, the use of applications as a focal point of instruction, and the use of projects - while certainly supported by the UCSMP materials, seem rooted at least as deeply in the content of the two summer workshops in which Kathy had recently participated.

*The use of technology.* Both of the workshops that Kathy attended during the summer of 1993 emphasized making use of calculators and computers in the teaching of mathematics. Kathy had, available in her classroom, an overhead projector, a scientific calculator for the overhead, six graphing calculators, a Macintosh computer
with an LCD palette for projection on the overhead, and software to emulate a graphing calculator with the Macintosh computer. However, I rarely saw Kathy actually use any of this technology in her teaching, and when I did, it was the scientific calculator on the overhead alone that I saw used. Most of the evidence that I have of such use is second-hand, coming from her journal or our interviews.

In January 1994, she wrote in her journal that "UCSMP has encouraged me to use more technology." This statement was possibly related to the emphasis on technology that appears throughout the UCSMP Secondary Component. However, it was noted in the previous section that Kathy feels constrained from utilizing technology in her UCSMP classes to the full extent that she would like.

Kathy apparently felt no such constraint to using technology in her classes that were not using UCSMP materials. During the March 1994 interview, I asked if she had been able to utilize her graphing calculators. Her response indicates that she had used them in her non-UCSMP classes:

I've used the TI-82 with my Course 2 classes. We have been doing parabolas, and I showed them how to make a quick table. The TI-82 does a wonderful little table; from 0 to 6, here's the table. These are the answers you should have gotten. It was a little faster, and then the graph was instantaneous. I've been doing a lot of graphing with my Course 2s, and I've used the graphing tools I have on the computer to do that, too.

What particularly fascinates me about this response is that the Course 2 classes to which Kathy referred were also a new assignment for her. The curriculum for this course is an integration of geometry, algebra, probability and statistics that is customarily taught in the second year of high school in this district. The approach is quite traditional. Yet Kathy apparently found the means to use graphing utilities in these classes, but not in the UCSMP Algebra classes.

During the interview in December 1993, I verified that Kathy had an overhead calculator that matched the scientific calculators that her students were using, and asked
her how she had been able to utilize it. She told me: "Yeah, I do have one. When I'm first doing a new thing, the first thing when I do it, I usually have the overhead out. When I'm explaining a new process, I will have the overhead out." When I asked during our February 1994 interview whether she had made any further use of her scientific calculator for the overhead projector, she replied: "There's days where it's a lot of computation, I'll get the calculator out, so the kids actually see my key-strokes."

During my visit to her classes in March 1994, this was precisely what I observed.

In February 1994, I also asked Kathy to elaborate on her uses of technology, other than the scientific calculators. Her reply described as much promise as action:

Occasionally, I use the computer when I want to do a lot of graphs, to show them quickly. But what I plan on doing is trying to get the graphing calculator implemented in this chapter. Because, I want them to be able to do a scatter plot, and I have a project-type thing that we developed at one of the workshops last summer.

It is reasonable to suggest, as did Kathy herself, that her increased use of technology was related to her use of UCSMP materials. It is likewise just as reasonable to suppose that this factor was equally related to the content of the summer workshops that she had recently completed. Moreover, it seems likely that Kathy will begin to utilize technology in her UCSMP classes as she gains familiarity with the new materials. Certainly the intention to do so is there, as are the means.

*The use of applications.* During the November 1993 interview with Kathy, she described for me one of the two workshops she had attended that preceding summer:

That one was trying to bring in real life situations into the various different courses, and it was from a technology point of view. It's a two summer program, four weeks this summer, and four weeks next summer. And next summer, what they plan on doing is splitting us up into content areas, and we would work just on making up lessons, using real-life situations.
This was a good fit with the UCSMP materials that she found herself implementing, as those materials also contain a focus on the practical applications of mathematics (UCSMP, 1989, p.4).

Kathy believes that applications play a significant role in her instruction, and she recognizes the motivational aspect of an applications approach. In a January 1994 journal entry, she hypothesized that: "If students can see where they can use things in real life, they are more willing to do the work."

As was the case with the instructional use of technology in Kathy's classroom, it is impossible to determine whether the changes she made in the way of an increased focus on the applications of mathematics are related to the UCSMP implementation or her participation in the summer workshop. Most likely, it is some combination of the two.

The use of projects. Kathy spoke of an interest in projects during our first interview in September 1993: "I'd like to get more project oriented, where the kids go home and do experiments and do different things - using what they've learned - but in an experimental, project-type form. It's not just doing textbook questions, but getting some real applications." Given that the workshop in which she participated just weeks earlier had focused on the use of real-life situations, and that at this point in the year she was still relatively unfamiliar with her UCSMP Algebra textbook, my guess is that the source of this initial interest in projects was the summer workshop and not UCSMP.

However, UCSMP would tend to support such an orientation, and as noted in the case of Gina, in this district, it was decided by the teachers using the UCSMP materials that a project would be a required portion of the district-wide final assessments in the UCSMP courses. The project that Kathy first utilized was described earlier in the section regarding the use of technology. Kathy decided to fit
the project into her schedule in place of the chapter review that customarily preceded each chapter test. In order to accommodate the chapter test, it was given as a "take-home."

Even in this project-oriented format, Kathy found it difficult to use the technology as she originally intended. In March 1994, after the project had been concluded, she provided the following perspective: "We did a project, scatter plots, for algebra. And I wanted some of the kids to try to do one of the graphs on the calculator. But they got so involved in the project that they didn't get to the calculator." Kathy seemed pleased with her students' responses to the project, noting that: "only a couple of people didn't get it in on time." When I asked her directly how she felt about the project, her reply confirmed my sense of her satisfaction: "I like it. Next year, I put in for the new Applied Math course, and that's all based on projects. I'm real excited about it!"

Focus on Procedures

Unlike Diane and Gina, both of whom exhibited some tension between procedural and conceptual knowledge during my study of their UCSMP implementation, Kathy's teaching showed a decided focus on the procedural aspects of mathematics throughout her first year of using the UCSMP materials. This focus on procedures first became apparent during the September 1993 interview. I was probing some of her responses to a survey which she completed for me during the summer of 1993. Specifically, I asked her why she had responded "Strongly Agree" to the statement, "In learning math, students must master topics and skills at one level before going on." Note the role of understanding and doing in her account:

I think if they don't get it at first, they'll have a hard time when they see it again. They should understand what they're doing before they try to do something else, especially in algebra, because so many things rely on being
able to do what we have previously done. So, if you can't do that stuff, I'd see it as difficult to do the next stuff.

Despite the mention of understanding, Kathy's emphasis on "doing" was a portent of things to come.

The fieldnotes of my observations of her teaching are filled with references to an orientation toward rules, procedures, and the generation of correct answers. A lesson in November 1993 that dealt with the solution of linear inequalities provides a good example. At the end of my description of that lesson, I wrote: "I notice that the discussion seems focused on the procedures used to 'get something by itself.'"

Furthermore, on many occasions, Kathy failed to use concrete or visual examples - even when doing so would have been relatively easy to do. Two examples here will help to show the consistency of this pattern. The first occurred in September 1993 during a lesson on probability. My fieldnotes contain this description:

One of the students had trouble seeing that (6,3) and (3,6) are not the same outcome when rolling two dice. Kathy's explanation was OK, but there seems not to have been any thought of actually modeling it with two different-colored dice (i.e., they talk about probability situations, but they don't do any probability situations).

When I visited in December 1993, nearly three months later, the topic of the lesson was a "loop" in computer programming. I described this segment of the lesson in the following terms: "Kathy explains to them what a loop does. She makes frequent reference to the text in doing so. I notice that she does not make or refer to any sort of drawing or diagram." At this point, I added a parenthetical question to my notes: Would a flowchart have helped here? I asked Kathy just that later in the day during the interview. Her reply was: "No! They would look at me and say, 'What are you doing? You are nuts!'"

I thought it important to link this focus on procedures to Kathy's interpretation of the important content of school mathematics. In an attempt to do so, during the first
interview, I asked her, "What math do middle school kids need to know?" After a long pause, she replied:

I think they should know orders of operations, some basic algebra skills, such as solving one-step and some simple two-step equations, how to use the calculator. I want them to have the idea that everything isn't positive. You can get a negative answer and it's OK. You can get a decimal answer and that's OK. It doesn't have to be a nice answer. I don't want them to be afraid of math. Some probability. Formulas and how to use them; things like that.

Much of the content that Kathy mentioned is procedural and focused on the generation of answers. There is no mention of statistics or data analysis, although she might have implicitly included this when she mentioned probability, no mention of geometry or arithmetic, and, although algebra is mentioned, unifying concepts such as pattern, variable, and function are not.

That this procedural description of the important content in algebra was not simply an oversight is confirmed by a journal entry in January 1994. I had asked Kathy to write about the "big ideas" of algebra. My questions and her written responses follow:

**Question:** What does it mean for a student to *understand* a mathematical topic?

**Response:** Knowing the procedure to get the desired result and when to use that procedure.

**Q:** What are the two or three most important things that your Algebra students should understand at the end of the year?

**R:** (1.) Concept of solving equations, (2.) that algebra is used in real life, and (3) the calculator is an aid and how to use it.

**Q:** Pick one of these; how do you go about achieving student understanding of this thing?

**R:** Solving equations - visualization and keep the same procedure every time.

**Q:** Do you use concrete representations or visualization to help students to understand?

**R:** Visualization - use circles and arrows to help picture the process - begin with a scale.
Q: If so, could you give me an example?

R:

\[
2x + 5 = 4x - 8
\]

\[
2x - 4x = -8 - 5
\]

Q: How might students demonstrate their understanding?

R: When given any type of equation, be able to explain process for solving; then solve.

Once again, the focus is on the solution of equations as the important content in algebra, and her example of visualization is quite procedural in nature. Notice, too, the procedural focus in the assessment of student understanding.

Kathy’s statement linking student understanding with ”knowing the procedure” when coupled with my interpretation that her instructional decisions are made in the best interest of her students, as she perceives their best interest to be, provides both an explanation for, and a confirmation of, her procedural focus.

Adapt, Rather Than Adopt

Over the past five years, nearly every teacher with whom I have discussed the implementation of UCSMP materials has indicated some degree of frustration with the reading expectation of UCSMP. Many have begun to teach reading strategies in their mathematics classrooms. Almost all of them have spoken of changes in their classroom routines that were inspired by the problem of initiating the reading of the mathematics textbook by their students.

As I began my observations of Kathy’s practice, I noticed many of the same kinds of frustrations and attempts at their resolution with which I was familiar from my own work as one of the original UCSMP pilot teachers in this district and from my
study of Diane's practice the year before. As Kathy's resolution of the "reading problem" unfolded, it became clear that rather than adopting the UCSMP approach, she was adapting it to fit her perception of her students' needs.

In Kathy's first journal entry, dated 24 September 1993, she wrote: "I find this a difficult course from a teacher's perspective. I feel as though I am not teaching, and that is frustrating. Hopefully, I will get the students reading on their own shortly." So that there could be no question about the meaning of her frustration, I intended to ask Kathy directly about the source of her frustration when I interviewed her in October 1993. However, an emotional upheaval in Kathy's personal life forced me to postpone that interview until the next month. To compensate for the lack of an interview in October, I asked her to address some specific questions in her journal. The source of her frustration was one of those. On 30 October 1993, she wrote: "The cause of the frustration is not explaining material, but having to read the lessons in class. When students are not successful, I feel that it is because I have not explained the material. I feel time is being wasted reading aloud in class." When we finally were able to address this issue of reading during the November 1993 interview, Kathy observed:

They have a hard time reading, a very difficult time, and I think when I was so frustrated to begin with, it was because we were reading in class. But we weren't getting through the entire lesson by the time we went over the homework, and they weren't finishing. And so I was feeling that reading in class was wasting time. Because, if they're not going to finish, then they're not going to know the material that's going to be on the homework. So I felt it was better for me to assign the reading, hoping that they will do it, but if not, that they'll at least be able to explain what they should have read. At least now, they're getting a little bit of what the lesson is about.

Thus, Kathy's solution was apparently to assign each lesson to be read independently outside of class and hope for the best. By assigning the "Covering the Reading" questions from each lesson along with the reading, she seemed to be hoping that, if the
lessons were not being read in their entirety, at least they were being skimmed for the answers to those questions.

In February 1994, I finally asked Kathy whether the reading aspect of UCSMP in any way changed what she did in the classroom. She replied:

No; I hope the kids read it, but I know their comprehension skills are not what they should be. And so I'm going to teach it the way I would have taught it if they hadn't read it. I'm going under the impression that the kids can't read an English book, so how can I expect them to read the math book and comprehend what this is saying? So what I'm doing is I'm going to teach the course the way I would have taught it.

With respect to the use of reading as an instructional strategy in mathematics, an important cornerstone of the UCSMP approach, it is clear the Kathy adapted the innovation rather than adopting it.

In so doing, Kathy was able to continue one of the roles that she viewed as central to teaching: to explain the mathematics content to students. In her account of the situation, also provided during the February 1994 interview, Kathy stated:

I think the reading just reinforces things, and because they're getting it while they're reading it, plus me, verbally telling them, that makes it stick better. If the kids read it, it's just going to reinforce what I'm saying out loud. And sometimes if they read it, then I can go back and say, "Well, this is now what this means, what you read. This is what it is telling you." And in terms they can understand!

And in the March 1994 interview, she confirmed this assessment: "I think it's just in the back of my head: They can't get it unless they see why, so I better make sure I show them why." Clearly, Kathy sees telling, showing, and explaining as important activities in her teaching, and has adapted the UCSMP materials to accommodate those activities.
Understanding Differences in the Case of Kathy

Having traced three important differences in my interpretation of Kathy's first-year experiences with a UCSMP curriculum vis-à-vis my interpretation of Diane's and Gina's experiences, it is important to consider possible reasons for those differences. The first possibility that I considered was a lack of peer interaction and support.

I had information - misinformation, as it turned out - that Kathy was not able to regularly attend the series of monthly UCSMP inservice meetings. I hypothesized that peer interaction and support, particularly of the form likely to be encountered at those UCSMP inservice meetings, might have nudged Kathy more in the direction of adopting, rather than adapting, the UCSMP materials. This, in turn, might have had the potential to induce changes in Kathy's practice.

As I probed more deeply, however, I learned that not only was Kathy a fairly regular attendee of the UCSMP inservice meetings, but that she had a well established network for peer interaction and support outside of those inservice meetings. In the March 1994 interview, we discussed this issue. She told me that she had only missed one of the UCSMP meetings. Next, I asked if she ever had the opportunity to interact professionally with any of the other four secondary mathematics teachers in her building. She replied:

A lot of that [interaction] is with the afterschool program, because kids who don't get their homework come to me, and I talk to the other teachers about their students that I see. And, with the Algebra, since we all use the same thing, a lot of times we talk about where we're at, what projects we were going to do, and things like that. After I go to the meetings once a month on Saturdays, too. The people that don't go, I usually come back and tell them what I found out.

Then, I asked her to tell me about any other opportunities for peer interaction and support that she utilized, but of which I might not be aware. Kathy's response leads me to believe that she has a well-developed network for peer interaction and support:
There's a girl at [names another school in the district] who went to a TRANSIT Program with me on the technology, and we have meetings every three months, which is good, because it's not just the teachers from our district, it's teachers from the whole area. And you get to talk to them about different courses, and then, when we had a conference here, all of the people from [the other summer workshop] went to the conference and we sat together, so that we could talk. So, in that aspect, when I first started, I had a mentor teacher, and I still call her when I have trouble. I'm like, "Pat! Help!"

In probing still more deeply into the data, I believe that I have uncovered three possibilities that are more tenable accounts for the differences in this case. The first is what I believe to be a divergence in Kathy's belief structure from that of the UCSMP authors. The second involves the content of Kathy's reflections about her practice. The third is similar to a cognitive overload: There were just too many forces of change exerting pressure on Kathy's instructional practice.

Divergence of Beliefs

Ball (1990) suggests that the adoption of the sorts of innovation implied in by the current reform effort in school mathematics "requires changed views of what mathematics is and what it means to know and do mathematics" (p.258). Moreover, Thompson (1992) believes that a research base exists which indicates that the behavior patterns characterizing teachers' instructional practices may derive from their beliefs about the nature of mathematics.

Kathy's focus on procedural aspects in her teaching of mathematics has been traced in a previous section. An examination of the UCSMP materials reveals that, while there is clearly an accommodation of these procedural aspects, there is also a focus on the conceptual aspects of mathematics. UCSMP has developed what they term the "SPUR" approach (UCSMP, 1992). This refers to what they see as four dimensions of understanding: Skills, Properties, Uses, and Representations.
Conceptual knowledge inheres in the properties and representations dimensions, but UCSMP describes these in terms that are designed to fit a variety of teaching styles. Thus, Kathy's focus on procedures is a partial misfit with the UCSMP philosophy which acknowledges the importance of both procedural and conceptual knowledge. On the other hand, the description of the SPUR approach contained in the UCSMP Teacher's Editions might have led Kathy to believe that she was, in fact using a SPUR approach. Clearly, she was focusing on skills (procedures) and uses (real-life situations). In a manner similar to the analysis that Ball (1990) suggests in her discussion of the case of Carol Turner, it may be that Kathy reflects enough aspects of the UCSMP SPUR approach as to deflect any serious consideration of change when she reflects on her instructional practices.

In order to gain a better understanding of Kathy's belief structures regarding mathematics itself, as well as mathematics learning and teaching, I devised a set of activities that were undertaken in the March 1994 interview. Because the issue was one of contrasting my interpretation of Kathy's practice with those of Diane and Gina, I conducted the same activities with Diane and Gina, also during the March 1994 interviews.

Drawing from Cooney's (1985) investigation of the relationship between a beginning teacher's beliefs and practices, I asked each of my teacher informants to list at least three adjectives or adverbs that describe, first mathematics, and then the process of learning and teaching mathematics. Next, following Ernest's (1989) notions about the impact of beliefs on teaching mathematics, I asked my teacher informants to select from three possibilities the one view of mathematics that best fit their own. These perspectives, which were adapted from Ernest's work and typewritten on index cards, were:
• Mathematics is a static but unified body of knowledge consisting of interrelated structures and truths. Mathematics is discovered, not created (A Platonist view).

• Mathematics is a continuously expanding field of human inquiry that is not a finished product, but open to revision. Mathematics is created, not discovered (A dynamic, problem-driven view).

• Mathematics is a useful collection of facts, rules, and skills which can be brought to bear on a wide range of human endeavors (An instrumentalist view).

Both Diane and Gina selected the dynamic, problem-driven view of mathematics, while Kathy selected the Platonist view. Their lists of adjectives and adverbs, which appear in Table 1, can be better understood against their underlying views of mathematics. There is a clear contrast between the descriptors of mathematics selected by Diane and those selected by Kathy. Diane's choice of the words "logical" and "invented" seem to imply human constructions, which makes them a good fit with her choice of the dynamic, problem-driven view of mathematics. On the other hand, Kathy's choice of "necessary" and "abstract" seem to imply a preexisting structure, and are thus a good fit with her choice of the Platonist view of mathematics. Moreover, Baroody and Ginsburg (1990) posit a link between direct instruction and the abstract qualities of mathematics. If they are correct, then Kathy's choice of "abstract" is also a good fit with her favored style of teaching.

Only Gina's word choices are difficult to interpret against her selection of the dynamic, problem-driven viewpoint. This is perhaps a result of her inability to clearly articulate her thoughts at the time that she was asked to create such a list. Her own frustration is evident in the following statement: "I'm not coming up with very specific
Table 1: Teacher participant's descriptors of mathematics and the process of mathematics learning and teaching.

<table>
<thead>
<tr>
<th></th>
<th>Diane</th>
<th>Gina</th>
<th>Kathy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjectives or adverbs to describe mathematics</td>
<td>logical</td>
<td>necessary</td>
<td>necessary</td>
</tr>
<tr>
<td></td>
<td>invented</td>
<td>important</td>
<td>abstract</td>
</tr>
<tr>
<td></td>
<td>broad</td>
<td>art and science</td>
<td>broad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>vast</td>
<td>fun</td>
</tr>
<tr>
<td>Adjectives or adverbs to describe the process of learning and teaching mathematics</td>
<td>inexact</td>
<td>collaborative</td>
<td>difficult</td>
</tr>
<tr>
<td></td>
<td>challenging</td>
<td>fun</td>
<td>necessary</td>
</tr>
<tr>
<td></td>
<td>never-ending</td>
<td>interesting</td>
<td></td>
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<td></td>
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<td>sequential</td>
<td>frustrating</td>
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</table>

words here ... [pause] ... ; Can I come back to this?" One way to interpret this lack of specificity is the possibility that Gina sees mathematics in less specific terms than do others; That is, her beliefs about the nature of mathematics are not so rigid.

Gina's choice of the word "collaborative" to describe the process of learning and teaching mathematics tends to confirm her problem-driven view of mathematics, particularly in light of her clarification that the learning and teaching of mathematics "develops from the teacher and the students working together." Moreover, Gina's use of the word "necessary" to describe the nature of mathematics was immediately
qualified by the words: "meaning important." This seemed to give Gina's use of the word a different sense from that implied by the interpretation of Kathy's use of the same word.

Ernest (1989) conjectures several links between teachers' views of the nature of mathematics and their mental models of the process of learning and teaching mathematics: "Mathematics as a Platonist unified body of knowledge corresponds to a view of the teacher as explainer, and learning as the reception of knowledge . . .; mathematics as problem-solving corresponds to a view of the teacher as facilitator" (p. 26). The fact that Diane and Gina, the two teachers who selected the problem-driven view, both have described their changing role in the classroom as becoming more of a facilitator, coupled with the fact that Kathy has frequently described her role in the classroom in terms of explaining, are evidence of the plausibility of Ernest's conjectures.

If the foregoing account of my participant teachers' beliefs about the nature of mathematics is correct, Diane's and Gina's beliefs are more in line with those of the UCSMP authors than are Kathy's. This allowed Diane and Gina to adopt the innovative UCSMP materials in ways which the authors might have envisioned. Because Diane's and Gina's beliefs proved to be a good fit with the UCSMP materials, they were able to resonate with those materials and make instructional changes in doing so. On the other hand, Kathy must have sensed a mismatch between her beliefs and the UCSMP materials, which led her to adapt the materials to fit her existing belief structure. This account provides one possible explanation for the differences in the nature of the changes observed in Kathy's practices compared with those observed in Diane's and Gina's practices.
Content of Reflection

In analyzing the case of Kathy, I began to suspect a link between Kathy's reflective activity and the nature of the changes in her practice. My first interpretation was that she quite possibly does not reflect on her practice of teaching in the same depth that Diane and Gina do.

However, upon further analysis, this interpretation was discarded. In probing the data that I had collected, especially my interviews of Kathy, I found too much evidence to the contrary. For example, in discussing the efficacy of using real life situations to make learning fun, Kathy stated: "I believe that kids learn better when you make it fun, [because] if you make it fun and interesting for them, they tend to cooperate more." Another example can be seen in her justification for sometimes deviating from the textbook approach: "I've found that sometimes the way that the textbook illustrates things is not what kids have seen in the past or what they understand best."

Further evidence of the depth of Kathy's reflections can be seen in her account of the importance of presenting mathematics in ways that are understandable to students: "If they don't know what the material means, or what words are, or if you don't relate it on their terms, then they don't remember it." In this instance, she has related student understanding with the problem of retention.

Examples such as these seemed to render implausible the interpretation regarding a lack of depth in Kathy's reflective activity. Richardson (1990) suggests that "if we are interested in change that is significant and worthwhile, the content of reflection should relate to standards of appropriate classroom practice" (p. 13). A reexamination of Kathy's reflective activity with an eye to the content of her reflections suggested a second interpretation.
I now believe that Kathy, while perhaps reflecting as deeply on her practice as do Diane and Gina, reflects on different concerns than they. In particular, Kathy's reflections seem focused on how to make learning mathematics fun for her students, how to explain procedures and concepts to students, and how to help students to quickly and reliably generate correct answers. Each of these concerns is understandable in light of the context of Kathy's practice of teaching.

It was noted in a previous section that much of Kathy's classroom activity is in response to her desire to make learning fun for her students. This factor surfaced many times in the interviews, particularly when we discussed effective mathematics teaching. As was posited earlier, Kathy's beliefs in this regard probably derive from her recollections of the teacher who inspired her to become a teacher.

Likewise, the importance in Kathy's philosophy of the teacher explaining mathematical content to students has previously been traced, as has the procedural focus that her instruction often takes. The convergence of these two focal points, the teacher explaining procedures, clearly provides plausible substance for Kathy's reflections on her practice.

In addition, there is the strong possibility of an interaction between Kathy's network for peer interaction and support and the content of her reflective activity. In an informal discussion with Ms. Riter, the district's director of mathematics, in which I sought to confirm the existence of this network of support, I learned that substantial portions of it, the mentor teacher and the other mathematics teachers at Kathy's school, might be described as more traditional teachers who tend to place a heavy emphasis on procedural knowledge. At any rate, this was Ms. Riter's interpretation.

Finally, I believe that Kathy's interest in helping students to generate correct answers, which is almost a preoccupation at times, is quite natural given the nature of
her experience in teaching. Most of the courses that Kathy has taught (the UCSMP Algebra course is a notable exception) come complete with state-wide syllabi. Moreover, all of the students in these courses are required to take a state-wide final examination with between 60% and 100% of those examinations multiple choice or short answer questions allowing no partial credit for incorrect answers. This experience probably not only suggests a reason for her strong interest in helping students to generate correct answers, but a possible explanation for the procedural focus of her instruction as well.

At the same time, neither Diane nor Gina, both of whom are middle school teachers, has had the experience in a high school setting that gives rise to these sorts of emphases. Hence, neither of them exhibited nearly the same degree of interest in correct answers nor the procedural focus that was evident in Kathy's work. Moreover, although I am sure that they would agree about the importance of making learning fun, they rarely, if ever, mentioned this issue when we discussed the process of learning and teaching mathematics. Thus the interpretation that the content of Kathy's reflective activity differs from that of both Diane and Gina seems tenable.

Too Many Forces of Change

Fullan (1982, 1991) observes that significant change involves a degree of ambiguity, ambivalence, and uncertainty as the individual implementers work out the meaning of the innovation for themselves. In his view, change is a process, not an event, and it is a frustrating, discouraging business that requires a significant investment of time. From this perspective, the notion of a "change overload" is an easy step to take. It is reasonable to suggest that an individual who is faced with a number of competing forces of change may simply be unable to deal with all of them.
simultaneously. This seems to have been the case with Kathy during her initial year of UCSMP implementation.

From the beginning of my study of Kathy, I was aware of three forces of change that were working on her practice. The first of these forces derived from the innovative UCSMP materials themselves. If the interpretation that the UCSMP philosophy is not in complete alignment with Kathy's beliefs about the nature of mathematics is correct, this force of change probably caused Kathy a good deal of ambivalence and uncertainty.

The second force of change that was acting on Kathy was an impetus to make greater instructional use of technology. The source of this force lay in Kathy's participation in the two summer workshops. An account has already been provided of Kathy's frustration at being unable to utilize technology in her UCSMP classes to the extent that she desired, despite the UCSMP position favoring such utilization.

Using real-life applications as a focal point of instruction in mathematics was the third force of change acting on Kathy's practice. This force also derives from Kathy's participation in a summer workshop. As was previously documented, Kathy did implement some change in this direction. In this case, the UCSMP philosophy not only favors such a focus, but an emphasis on real-world problem situations as a basis for instruction is incorporated in every UCSMP textbook. With real-life situations a built-in feature of the textbook that she was using, it is reasonable to conclude that the two forces of change complemented one another as Kathy exhibited some change in this area.

There turned out to be a fourth force of change which acted on Kathy during the year of the study, although I did not learn of it until the March 1994 interview. At that time, Kathy related the following: "We've done things with learning styles lately, and
so I've been trying to do some things with that in mind. We've heard so much
learning-learning-learning styles, and maybe I'm just doing it now because it's been
drilled so much lately." I probed further, asking if learning styles had been the
substance of one of the inservice meetings. She continued:

Yeah. And I went to a couple of meetings that were on study skills, and they
talked about the different [learning] styles there. We had one of the in-school
day conferences. They talked about learning styles there, too, and about how
you need to address those issues.

Thus, there were no fewer than four major forces for change simultaneously
competing for Kathy's attention. The wonder is not that she was only able to
effectively deal with one of them, but that she was able to deal with any of them at all.

For Diane and Gina, there seemed to be only the one primary force for change,
the UCSMP implementation. In the case of Diane, it is true that she participated in a
series of cooperative learning workshops during her first year of the UCSMP
implementation. However, it is clear that she viewed cooperative learning and the use
of UCSMP materials in a complementary fashion. Moreover, it is possible that the
original impetus that gave rise to her participation in the cooperative learning
workshops derived at least in part from her use of the UCSMP materials.

In the case of Gina, the only other possible force for change of which I was
aware was her graduate work in TESOL. However, her studies in this area began the
year before her UCSMP implementation, so it is quite possible that she had already
begun to make changes in her daily practice to accommodate her TESOL studies.
Moreover, the evidence suggests that Gina was well aware of the complementary
nature of those studies and the reading aspect of the UCSMP materials.

Thus, while Kathy struggled to balance no fewer than four major forces of
change, Diane and Gina were probably only dealing with one such force. At most,
Diane and Gina were simultaneously dealing with two such forces that were complementary.
Summary

The case studies of Diane, Gina, and Kathy demonstrate some similarities and differences when viewed across cases. In all three cases, problems with time management in the implementation of the new materials and a lack of familiarity with those materials acted as constraints to change.

The cases of Diane and Gina were the most alike. They exhibited similar emergent themes:

- Both were seen to be reflective practitioners.
- Both are structured teachers.
- There is a tension between procedural and conceptual understanding in both of their practices.
- Both appeared to be in a transition from a transmission of knowledge model of instruction toward a negotiation of shared meanings model of instruction.
- Mathematical connections began to take on a more prominent role for both as the year progressed.
- The UCSMP text was both an agent of, and a constraint to changes in both of their practices.

Additionally, in the case of Diane, it was suggested that she began her UCSMP implementation with a predisposition to make changes in her instructional practices.

In both the cases of Diane and Gina, the ways in which the innovative UCSMP materials seemed to have facilitated change were also similar. These included:

- an increased use of cooperative learning strategies,
- the use of student reading as an instructional strategy,
• an increasing prominence for mathematical connections,
• a transition toward the negotiation of shared meanings, and
• a changing role for the teacher herself.

In addition, Gina developed an interest in the use of student projects as instructional devices, as did Kathy. The other changes in Kathy's instructional practices were an increased interest in utilizing technology in instruction and the use of mathematical applications as a focus of instruction.

The case of Kathy differed from the other two cases in three general areas:
• Kathy's practice of teaching showed evidence of different sorts of change.
• Kathy focused on the procedural aspects of the material in the UCSMP textbook.
• It appeared that Kathy adapted, rather than adopted, the innovative UCSMP materials.

Finally, several interpretations were made in an attempt to account for these differences. It was suggested that these differences derive from:
• a divergence in Kathy's belief structure from those of the UCSMP authors,
• differences in the content of Kathy's reflective activity, and
• too many forces of change exerting pressure on Kathy's instructional practice.

Table 2 displays the major points of this summary viewed in matrix form across cases.
Table 2: A Cross-Case Comparison of Interpretations and Findings

<table>
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<tr>
<th></th>
<th>DIANE</th>
<th>GINA</th>
<th>KATHY</th>
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<td>transition to</td>
<td>explainer or</td>
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<td>Type of Change</td>
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<td>connections</td>
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<td>4. use of projects</td>
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<td>5. use of technology</td>
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<td>7. negotiation of</td>
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<td>8. tension between</td>
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<td>4. reflective activity</td>
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<td>5. interactions with</td>
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<td>the researcher</td>
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<td>6. summer workshops</td>
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CHAPTER VI

DISCUSSION OF THE INTERPRETATIONS AND FINDINGS

"Meanings are handled in, and modified through, an interpretive process."

- Herbert Blumer (1969, p. 2)

This discussion will be organized around four major points. The first will be a consideration of the specific research questions that were posed in Chapter I, examined in light of the interpretations and findings of this study. Next, the major findings of the study will be enumerated and linked with the current research literature on teacher change, and implications that derive from these findings will be explicated. This will be followed by a reconsideration of the problem of the construction of a model to assist in understanding the process of change in teaching practice. Finally, implications for further research will be suggested.

The Research Questions

This study speaks to each of the research questions that were posed in the first chapter. Those questions are:

- When an innovative curriculum such as UCSMP is implemented by three experienced secondary mathematics teachers in a large urban school district, what changes do those teachers make in their instructional practices?
- If such changes do occur, to what might they be attributed? In particular, do other teachers and administrative support, as well as the innovative curriculum materials themselves play a role in the process of change?
• What are the similarities and differences in the process of change in classroom practices when two consecutive years of a UCSMP implementation are compared?

Each of these questions will be considered in light of the case studies that were developed in the preceding chapter.

The evidence clearly supports the conclusion that Diane and Gina made similar changes in their instructional practices as they implemented the innovative UCSMP materials. Particularly noticeable were changes that enabled and complemented a changing role as teacher. On the other hand, the evidence suggests that the process of change operated differently on Kathy's instructional practice.

The specific changes that occurred in Diane's and Gina's practices included greater use of cooperative learning strategies, the use of reading as an instructional strategy, an increased attention to the development of mathematical connections, and a transition toward the negotiation of taken-as-shared meanings with students. It is noteworthy that these changes all suggest a role for the teacher that differs from the traditional role as a transmitter of knowledge. Indeed, the classroom roles of both Diane and Gina shifted more toward that of a facilitator of learning.

The changes that Kathy exhibited were an increased interest in utilizing technology in instruction, an instructional focus on the applications of mathematics, and the use of a project as a tool for learning. Gina also made use for the first time of projects as learning devices. Given that the project that Kathy selected was rooted in a real-life application of mathematics, it is likely that the focus on applications and orientation toward projects are interrelated in her case.

As these changes unfolded, a number of sources to which they might be attributed suggested themselves. In the case of the use of reading as an instructional
strategy and an increased attention to mathematical connections, the use of a UCSMP
textbook seemed clearly to be the impetus for both Diane and Gina. The use of the
UCSMP textbook seemed to be the source of Gina's greater use of cooperative learning
strategies, as she strove to accommodate the UCSMP reading expectation with her ESL
students. On the other hand, there seem to have been two different sources of Diane's
interest in and greater use of cooperative learning techniques. The first, and I suspect
the primary source, was Diane's interaction with the researcher during the first
interview. It is likely that the dialogue concerning cooperative learning at least served
as the catalyst for the changes that followed. A second source, which tends to
complement the first, is the predisposition to change that was hypothesized for Diane.

The source of the transition toward the negotiation of shared meanings that was
observed in both Diane and Gina is a bit more difficult to pin down. That perhaps
follows from the more subtle nature of this change. One explanation which seems
plausible is an interaction between cooperative learning activities and the use of the
UCSMP textbook. As both of these teachers sought to develop their students' ability
to make sense of what they were reading and as they increasingly incorporated
cooperative techniques, there was much more student-talk in their classrooms. This, of
course, increased the need for Diane and Gina to interpret what their students were
saying. As it became increasingly clear to them that their students were indeed capable
of constructing their own mathematical meanings, I believe this process of negotiation
began to take root in each of their practices, perhaps unconsciously at first. At some
point, however, I believe that each of them came to the realization that there was
something powerful occurring in her classroom - something that was then consciously
pursued.
The shift in teaching role that Diane and Gina were observed to make is also a subtle change, but I think more easily explained in light of the other changes that they were making. The use of cooperative learning strategies and the transition toward the negotiation of shared meanings both are more student-centered than teacher-centered activities. Thus, they cast the teacher in a different role, as a facilitator, rather than a teller or explainer. Moreover, if students are seen to be able to read a mathematics text independently and make sense of it, there is less need for the teacher to provide and explain the content and more opportunity for her to facilitate its understanding. Finally, as mathematical connections take a more prominent role in instruction, and as the teacher sees her students actually making such connections, it seems a natural step to see those students as capable of constructing meaning. This also supports the teacher's changing role in the classroom. Thus, the transformed role that was observed for both Diane and Gina was a natural extension of the other changes that they were making.

The changes that Kathy made were different from those observed in Diane and Gina. The project orientation that Kathy espouses, particularly when set in contexts that are meaningful and of interest to students, suggests the sort of student-centered activities that may well, in time, also engender a shift in Kathy's role in the classroom. It seems clear that the primary source of the changes that Kathy made was her participation in the TRANSIT and real-life applications workshops during the summer immediately preceding the study. Because they are a good fit with the UCSMP philosophy and materials, it is plausible to conclude that Kathy's use of the UCSMP textbook supported an impetus to change that was rooted in her participation in the summer workshops.

Each of these teachers spoke at some point about the value of the peer interaction and support that they received from colleagues at the monthly UCSMP
inservice meetings. In particular, Diane indicated an interest in establishing a broader network for such interaction and support. Gina indicated that these two factors alone made it worth her while to attend the inservice meetings. Kathy found the feedback from experienced UCSMP implementers, other teachers like herself, to be helpful in dealing with the frustrations inherent in the implementation of such an innovation. It seems likely that this peer interaction and support provided a context within which these teachers could work out the meaning of the UCSMP implementation for themselves. In this sense, their interactions with peers are a form of symbolic interaction in which meanings are "social products, ... creations that are formed in and through the defining activities of people as they interact" (Blumer, 1969, p. 5).

The district's Director of Mathematics, a sort of internal consultant, to use Fullan's (1991) term, organized and attended the series of UCSMP inservice meetings. In a sense, she thus became a part of the interactive support network that these meetings provided for the UCSMP implementers. But more than this, the active support and participation of this district administrator, the person who is responsible for mathematics education throughout the district at every grade, must have validated these teachers' efforts and given them a sense of worth, thus priming their responsiveness to the innovation they were faced with implementing.

It has been shown that the innovative UCSMP materials did enable changes in instructional practice for Diane and Gina. In the case of Kathy, the UCSMP materials seem to have at least supported change in the areas where it was observed. The difference in this case seems related to a lack of fit between Kathy's underlying beliefs about the nature of mathematics and the underlying philosophy of the UCSMP series. It is interesting to note that the innovative materials also acted as a constraint to change, and that this constraining feature was observed in each of the three teachers. In all
cases, however, these constraints were related to time management and the
unfamiliarity of the new materials and may therefore disappear in time as these teachers
gain experience with the innovation.

Diane's practice was studied over the course of two consecutive school years. The process of change in her instructional practices exhibited some similarities and differences when viewed across those two years. The features observed in the second year that were similar to the first included a continued interest in the use of cooperative learning strategies, a continued and increasing movement toward the negotiation of shared meanings with students, and the continued shift in roles that derives from changes in these two areas. The features different from the first year included an increase in the actual use of cooperative strategies in Diane's UCSMP classes, a diminished role for mathematical connections in her instruction, and greater difficulties in using student reading as an instructional technique. These latter two differences seemed related to differences in the particular groups of students with whom she dealt each year. Indeed, Diane herself stated her belief that student behavior was the basis for these two differences.

The question of whether Diane showed more or less evidence of change in the second year relative to the first is difficult to answer and is perhaps the wrong question to ask. It is difficult to answer, because the subtle nature of many of the changes that were observed in her practice renders those changes difficult to quantify. It may be the wrong question, because it does not adequately account for the temporal aspect of change. A better question to ask is whether Diane continued to change during the second year and whether she began to grow into those changes. This question seems more in line with Fullan's (1982, 1991) idea of change as a process, not an event. The answer to both parts of this question is clearly a resounding yes. Moreover, I would
guess that the process of change in Diane's practice that is traceable to her involvement with UCSMP is not yet complete.
Major Findings

This research resulted in six findings which may be characterized as major, because they provide further confirmation of earlier research, have important implications for teacher change initiatives, or both. These important findings are:

- Use of the innovative UCSMP textbooks and materials acted to both enable and inhibit changes in mathematics teachers' practices.
- There was most likely an interaction with the individual teacher's beliefs about the nature of mathematics during the UCSMP implementation.
- The changes in practice that did occur were the result of a reflective process.
- Peer interaction and support were seen to be an important feature during the implementation of the innovative materials by each of the teachers in this study.
- The case of Kathy suggests that it is possible for a teacher to encounter a "change overload."
- All three of the teachers in this study demonstrated the accuracy of the assertion that change is a frustrating, discouraging process that requires time.

The implications of each of these findings will be discussed and, where possible, each will be placed in the context of the existing research on change in mathematics teachers' instructional practices.

Enabling and Inhibiting Change

A number of recent studies of change in mathematics teachers' instructional practices have applied constructivist ideas to the problem of change in the practice of
teaching mathematics (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Shaw & Jakubowski, 1991; Simon & Schifter, 1991; Wood, Cobb, & Yackel, 1991). From this perspective, teachers are seen as active problem solvers who construct and reconstruct their own understandings of the complex problems of teaching through an interactive process of interpretation. Fundamental to this position is the notion of perturbation, or a disturbance to existing knowledge structures.

It was found in two of the cases in this study that the innovative UCSMP materials were an enabling factor in the process of change in those teachers' practices. I believe that teachers' regular use of the Teacher's Editions of the UCSMP textbooks brought them into periodic contact with subtle hints and suggestions that are provided in the Teaching Notes that accompany each lesson in the textbook. These notes cover a variety of topics, including reading, making connections, small group work, alternative assessment, and extensions. Moreover, applications of mathematics are a focal point of the UCSMP textbooks, and the appropriate use of calculators and computers is assumed.

It is possible to account for this interpretation that the innovative UCSMP materials foster changes in teaching practice in a manner which is consistent with constructivist thinking. These teachers' daily interactions with the innovative textbook and materials required them to interpret the innovation on a regular basis. This may well have provided a source of continuing perturbation in their understanding of their own practices.

If this analysis is correct, it carries a strong implication for those interested in effecting significant, fundamental changes in teaching practice. In addition to the classroom activities that a change initiative program might present to participants, a thoughtful, well-constructed set of written materials with which participants might
regularly interact could provide a context for the sort of perturbation that can lead to change.

It was also found in all three cases that the innovative UCSMP materials sometimes acted to inhibit change in teaching practice. This constraint was manifested by time management problems that were often exacerbated by a lack of familiarity with the UCSMP materials. The pacing of lessons that is suggested by UCSMP, one lesson per day with two or three days of review at the end of each chapter, seemed especially problematic for teachers.

It has been suggested that successful change initiatives require an adequate investment of time (Fullan, 1982, 1991; Schön, 1983). This may be related to the time management problems that were noted above. It may have been that the teachers simply lacked the time to adequately plan their uses of the unfamiliar UCSMP materials in ways that more efficiently managed the available instructional time. Moreover, it is precisely this unfamiliarity that may have been the culprit. Quite possibly, teachers who were using the new materials for the first time needed to work out the meaning of the innovation for themselves. Thus, they were unable to spend enough time to adequately consider the problem of managing their own instructional time.

Once again this interpretation carries an implication for curriculum and textbook innovators. In large scale innovations, such as the district-wide implementation of an innovative textbook series, it is worth the investment in time and resources to provide contexts within which teachers might interact with and interpret the innovation before they are faced with the problem of implementation.

The ways in which the UCSMP textbook acted as an agent of or a constraint to change are summarized in Table 3. Each is paired with an aspect of the UCSMP Secondary Component textbooks to which it might be related.
Table 3: Features of UCSMP Texts That Enabled or Inhibited Change

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<th>UCSMP as: An Agent of Change</th>
<th>Related Textbook Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. cooperative learning groups</td>
<td>Teaching Notes: Small group work</td>
</tr>
<tr>
<td>2. student reading</td>
<td>A major focus of UCSMP; Teaching Notes</td>
</tr>
<tr>
<td>3. mathematical connections</td>
<td>Teaching Notes: Making connections</td>
</tr>
<tr>
<td>4. applications of mathematics</td>
<td>A major focus of UCSMP</td>
</tr>
<tr>
<td>5. use of technology</td>
<td>Appropriate uses of calculators and computers written into the textbooks</td>
</tr>
<tr>
<td>6. use of student projects</td>
<td>Teaching Notes: Extensions</td>
</tr>
<tr>
<td>7. negotiation of shared meanings</td>
<td>A derivative of points 1, 2, 4, &amp; 6</td>
</tr>
<tr>
<td>8. shift in teaching role</td>
<td>A derivative of points 1, 2, 4, 6, &amp; 7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UCSMP as: A Constraint to Change</th>
<th>Related Textbook Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. time management</td>
<td>Lesson pacing suggested by UCSMP</td>
</tr>
<tr>
<td>2. unfamiliarity with the innovation</td>
<td>The newness of the materials</td>
</tr>
</tbody>
</table>

Interaction With Beliefs

An adequate account of the difference in the sorts of change in practice that were observed in the case of Kathy relative to the cases of Diane and Gina is not possible without a consideration of these teachers' beliefs about the nature of mathematics. Duffy and Roehler (1986) have suggested that innovations are filtered through teachers' systems of conceptions and perceptions before they are implemented. In particular, they see teachers' beliefs about the subject matter content as one of those filters. In Fullan's (1982, 1991) account, the alteration of beliefs is one of three necessary dimensions of change in practice. Thompson (1984, 1992) acknowledges that teachers' beliefs about the nature of mathematics are fundamental in shaping their instructional practice. Ball (1990) suggests that changing teachers' beliefs is prerequisite to changing their practice of teaching, and Wood, Cobb, and Yackel (1991) found changes in teachers' beliefs central to changes in their practices.
In the present study, it was seen that Diane and Gina, the cases in which changes in practice were most similar, share a common belief about the nature of mathematics. Their conceptualization of mathematics as a dynamic, problem-driven field of human inquiry is compatible with that of the UCSMP authors. On the other hand, Kathy's static, Platonist view of mathematics is not. It was no accident that Diane and Gina exhibited the kinds of changes in practice that they did; the UCSMP materials supported their beliefs. On the other hand, the incompatibility of Kathy's beliefs with the underlying UCSMP philosophy implies that, before the UCSMP materials could perturb Kathy about her practice of teaching mathematics, they would have to perturb her beliefs about the nature of mathematics. To make the latter change is clearly more fundamental and, presumably, more difficult.

There is a clear implication for mathematics teacher educators in all of this. In order for teachers to fully comprehend the nature of the current reform effort in school mathematics education, it is necessary that they think carefully and explicitly about their own beliefs regarding the nature of mathematics. Teachers educators should provide teachers with opportunities to do just that.

*Change as a Reflective Process*

Teachers' reflective processes were demonstrated to be at work in each of the three cases in this study. This provides further confirmation of the power that researchers have almost universally attributed to teacher reflections (Schön, 1983; Shulman, 1986; Shaw & Jakubowski, 1991; Wood, Cobb, & Yackel, 1991).

The implication for those who would effect change in teaching practice is clear. Teachers need contexts within which to reflect on the innovations they are attempting to assimilate. In this way, they might work out the meaning of the innovation. Moreover, if the construction of meaning is seen as a social process, such contexts
necessitate social interactions with others who are involved with the innovation. This leads to our next point.

*The Importance of Peer Interaction and Support*

Throughout my experience with the UCSMP implementation in this district, first as a pilot teacher, then as an "old hand" - one who had "been through it all before," and finally as a researcher, I have become increasingly convinced of the crucial importance of opportunities for peer interaction and support during the process of change. The one common element upon which every teacher in this district who had implemented a UCSMP textbook and with whom I spoke agreed was this: When in the midst of frustration and despair regarding the implementation of the innovation, there is nothing quite so helpful as the sharing of thoughts, meanings, and actions with a colleague who is experiencing (or has experienced) the selfsame frustration and despair.

This confirms Fullan's (1982) assertion that "there is a strong body of evidence which indicates that fellow teachers are the preferred and most influential source of ideas" (p. 46). Moreover, it supports the conviction that teachers may not change if they exhibit all of the cognitive requisites to change, "but lack the benefits of support and collaboration" (Shaw & Jakubowski, 1991).

Again the implication is clear: Teachers must be afforded the opportunity for support and collaboration if they are expected to make substantive changes in their instructional practices. In fact, the idea of teacher collaboration within a change initiative has been suggested by Wood, Cobb, and Yackel (1991). This idea seems so closely aligned with the notion of a context for teacher reflectivity as to suggest that planned, regular collaboration with peers ought to be part of a teacher's normal working day.
Change Overload

In considering of the case of Kathy, I have posited the possibility of a "change overload." Fullan (1991) hints at this notion on a larger scale when he writes, "The greatest problem faced by school systems is not resistance to innovation but taking on too many changes indiscriminately" (p. 349).

During Kathy's first year of implementing a UCSMP textbook, she was simultaneously struggling to accommodate her practice of teaching to the foci of two recent summer workshops, as well as to show an increasing emphasis on learning styles. Each of these four factors carries serious implications for change in practice. Yet Kathy found changes in practice difficult to make, even when she had a clear desire to make them, as well as the means to do so. One possible interpretation is that of change overload: Kathy was simply driven by so many forces of change, that she was unable to act upon all of them. Indeed, she was barely able to act upon any of them. It is significant that the one area in which she was able to make a fair amount of change, an instructional emphasis on real-life applications or problem situations, was supported by one of the two workshops and was a built-in feature of the UCSMP textbook.

The possibility of a change overload implies that designers of change initiatives need to pay close attention to the number of forces of change with which the teachers in their programs must deal within a given time frame. Providing a single focus of change within an ample period of time will allow teachers, through their reflective activity, to construct their own meanings of the intended change. In so doing, those teachers will be better able to deal with the force of change.
A Frustrating, Discouraging Process

Fullan's analysis of the process of change (1982, 1991), developed over the course of a decade, suggests that change is both frustrating and discouraging. A certain amount of each was evident in all three cases in this study.

If frustration and discouragement are inevitable during the process of change, then successful change initiatives must anticipate and address these issues. Assuming that teachers in a planned program aimed at effecting changes in instructional practice will become both frustrated and discouraged, a synthesis of the previous suggestions and implications provides a means to address both problems.

Teachers need to have knowledge of the planned innovations. They need enough time to work out for themselves the meanings of the innovations. Because the construction of meaning is a profoundly social activity, teachers who would implement such planned innovations need a social context within which to construct their meanings. This suggests some format for support and collaboration with peers. Given such a social context, teachers' reflections on their attempts at innovation, in interaction with peers, might then become a source for perturbation followed by change.
An Evolving Model

In Chapter II, a simple model of the construction of knowledge was extended to the problem of teacher change. The resulting model of teacher change was modified in Chapter III by the addition of peripheral factors. Throughout the two-year period of the pilot study and the main study, as I became increasingly aware of both the importance and pervasiveness of reflective activity in the process of change in instruction, it became abundantly clear that neither of those earlier models of teacher change adequately accounts for teacher reflection. It now seems to me that reflective activity is the context within which the process of change takes place. I continue to see change as a cyclic process, but I now see reflection, rather than as just one of the points in the cycle, as the means by which those points are joined. Figure 4 illustrates this viewpoint.

Figure 4: Teacher Change as a Reflective Cycle
Now the six cognitive requisites for change that are identified by Shaw and Jakubowski (1991) can be mapped onto this model to account for the reflective turn between perturbation and change. In their view, the move from a perturbation to substantive change in practice requires a commitment to change, the construction of a vision of what that change looks like within the specific context of the individual teacher's practice, a projection by the individual teacher of self into that vision, and a decision to change within specific contexts. While I do not believe that the temporal order of these factors is either linear or fixed, neither do I believe that every permutation is a real possibility. Figure 5 captures one way to visualize the reflective turn between perturbation and change.

As the second year of the study progressed, it became increasingly clear that the process of change as it manifested itself in the case of Kathy was different from the process of change that I was observing in the cases of Diane and Gina. Then, as the issue of these teachers' beliefs about the nature of mathematics entered my analysis, it also became clear that the reflective cycle pictured in Figure 4 does not account for teachers' belief structures in the process of teacher change. I have come to believe that teachers' beliefs interact through a reflective process with each of the three points in that reflective cycle. Fullan's (1982, 1991) notion of the alteration of beliefs as one of three dimensions of change in practice suggested a means by which beliefs might enter the picture. Figure 6 is a three-dimensional model of teacher change in which the reflective cycle is shown balanced on a foundation of beliefs.
Figure 5: From Perturbation to Change - A Reflective Turn That Adapts Shaw and Jakubowski's Cognitive Requisites for Change into the Model
Figure 6: Teacher Change as a Reflective Cycle Based on Beliefs
Finally, I believe that not only does the process of teacher change involve reflections about the four vertices in Figure 6, but I believe that it requires one to reflect upon those reflections as well. Such second-order reflection seems to be what Skemp (1987) has in mind when he uses the term reflective intelligence. Others might be inclined to call this process metacognition. I place metacognition at the heart of the final model, which represents my current understanding of the process of teacher change, and which is illustrated in Figure 7.

Figure 7: Edwards' Model of Teacher Change
Implications for Further Research

The results of this study carry a number of implications for further research. One of the conclusions reached nearly universally by those who study the problem of teacher change is that substantive change in teaching practice takes time. The case of Diane confirms this assertion. She clearly continued to make changes in her practice of teaching during the second year of the study, and she herself anticipates that there is more change to come.

While some studies of change in mathematics teachers' instructional practices have covered more than one year, few, if any, studies of teacher change that used the same subjects throughout the study have encompassed the 3 to 5 years that Fullan (1982, 1991) suggests are necessary to the change process. There is a need for such truly longitudinal studies.

The present study suggests that innovative textbooks and curriculum materials such as UCSMP both enable and inhibit change in teaching practice. There are at least two related questions. The first concerns the nature of the UCSMP materials themselves. If these materials can act to enable change in practice, and the results of this study indicate that they can, then it is important to learn which precise features of those materials actually enable and foster the change. The second concerns beliefs. If the beliefs of teachers, especially those regarding the nature of mathematics, contribute to the process of change in practice, then it is important to learn whether the use of innovative materials like UCSMP will, over time, alter those underlying beliefs in any way. These are both important questions worthy of future investigation.
Finally, the possibility of a "change overload," which arose during the analysis of the case of Kathy, has received little research attention. On the other hand, there is probably an abundance of anecdotal evidence, not the least of which is the overwhelming feeling of inundation that frequently accompanies participation in workshops and conferences, that such an overload can and does occur. This question deserves further research attention.
Conclusion

The sorts of changes envisioned by the current reform effort in school mathematics education, of which the NCTM Standards are a major part, will require most practicing teachers to make fundamental changes in their instructional practices. If we in academe are to play a significant role in bringing about such change, we are going to need a much deeper, more complete understanding of the process of change.

The process of teacher change has remained intractable partly due to its complexity and partly due to the methods by which evidence must necessarily be accumulated. Shulman's (1986) arguments favoring the development of a case literature in teacher education are persuasive and ought to be extended to the problem of teacher change. Only by subjecting to public scrutiny a wealth of data amassed in a variety of classrooms concerning a great number of teachers who are struggling with the process of change can we hope to come to an understanding of this process ourselves. Without such an understanding, the current reform effort in school mathematics education is likely to go the route of previous such efforts.
APPENDIX A

DIANE'S SURVEY RESPONSES

Dear Colleague:

I would greatly appreciate your assistance in completing this survey. I will also be asking you to complete a similar instrument at or near the close of the 1992-93 school year. The information that you provide will be strictly confidential.

Please place your name on the line below. When I encode the completed surveys, I will assign a number to your survey and detach the cover sheet. The cover sheets and the surveys will then be stored in different files.

Tom Edwards

Your Name: ___________ Diane's responses, June 1992
Cohort group mean responses in parentheses (n=31).
Beliefs About Mathematics

Instructions: Indicate your agreement or disagreement with each statement below by circling the number that best reflects your belief.

**I. Your views about mathematics**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Not Sure</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I can handle basic math, but I don't have the kind of mind needed to do advanced mathematics.</td>
<td>1 2 3 (4.419)</td>
<td>* 4 5</td>
<td></td>
</tr>
<tr>
<td>2. A lot of things in math must simply be accepted as true and remembered; there aren't really explanations for them.</td>
<td>1 2 3 4 5 (4.516)</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>3. Math helps you learn to think better.</td>
<td>1 2 3 4 5 (1.258)</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>4. To be good at mathematics, you need to have a kind of &quot;mathematical mind.&quot;</td>
<td>1 2 3 4 5 (3.516)</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>5. There is more than one right way to get a right answer in mathematics.</td>
<td>1 2 3 4 5 * (1.161)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Mathematics is not a bag of tricks.</td>
<td>1 2 3 4 5 * (1.742)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**II. Learning mathematics**

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Not Sure</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. For students to get better at math, they need to practice a lot.</td>
<td>1 2 3 4 5 * (2.258)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. If middle school students use calculators, they won’t learn the math they need to know.</td>
<td>1 2 3 4 5 (3.935) *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. If students get into arguments about ideas or procedures in math class, it can interfere with their learning of mathematics.</td>
<td>1 2 3 4 5 (4.548) *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. In learning math, students must master topics and skills at one level before going on.</td>
<td>1 2 3 4 5 * (2.839)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Once students can reason abstractly, the use of models and other visual aids becomes less necessary.</td>
<td>1 2 3 4 5 (3.968) *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. How you get an answer is as important as whether the answer is right or wrong.</td>
<td>1 2 3 4 5 * (1.968)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
13. Average mathematics students, with a little guidance, should be able to discover the basic ideas of mathematics for themselves.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |

14. The teacher should consistently use activities which require original thinking.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |

III. Teaching Mathematics

15. If a student asks a question in math, the teacher should know the answer.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |

16. Being personally good at mathematical problem solving has little to do with being a good math teacher.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |

17. Basic computational skill and a lot of patience are sufficient for teaching middle school math.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |

18. Students should never leave math class feeling confused or stuck.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |

19. Teachers should not necessarily answer students' questions but should let them puzzle things out themselves.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |

20. The most important issue is not whether the answer to any math problem is correct, but whether students can explain their answers.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |

21. Teachers should follow the math textbook that is used in their school.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |

22. Teachers should spend most of each class period explaining how to work specific problems.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |

23. Students working in cooperative groups can learn just as well as from whole class instruction.  
   | Strongly Agree | Not Sure | Strongly Disagree |
   | 1 | 2 | 3 | 4 | 5 |
   |   |   |   |   |   |
IV. **Estimate the percentage of total class time that you spend on the following:**

(0% - 100%)

0 __ activities using manipulative models.
10 __ calculator/computer activities.
15 __ students working together in small groups.
20 __ going over homework assignments.
15 __ student explanations of their work.
20 __ students working independently at their seats.
20 __ teacher explanations of new material.
20 __ guided practice activities.
APPENDIX B
GINA'S SURVEY RESPONSES

Dear Colleague:

I would greatly appreciate your assistance in completing this survey. I will also be asking you to complete a similar instrument at or near the close of the 1992-93 school year. The information that you provide will be strictly confidential.

Please place your name on the line below. When I encode the completed surveys, I will assign a number to your survey and detach the cover sheet. The cover sheets and the surveys will then be stored in different files.

Tom Edwards

Your Name: Gina's responses. April 1993
Cohort group mean responses in parentheses (n=31).
Beliefs About Mathematics

Instructions: Indicate your agreement or disagreement with each statement below by circling the number that best reflects your belief.

I. Your views about mathematics

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Not Sure</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I can handle basic math, but I don't have the kind of mind needed to do advanced mathematics.</td>
<td>1</td>
<td>2</td>
<td>3 (4.419)</td>
</tr>
<tr>
<td>2. A lot of things in math must simply be accepted as true and remembered; there aren't really explanations for them.</td>
<td>1</td>
<td>2</td>
<td>3 (4.516) *</td>
</tr>
<tr>
<td>3. Math helps you learn to think better.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4. To be good at mathematics, you need to have a kind of &quot;mathematical mind.&quot;</td>
<td>1</td>
<td>2</td>
<td>3 (1.258) *</td>
</tr>
<tr>
<td>5. There is more than one right way to get a right answer in mathematics.</td>
<td>1 (1.616) *</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6. Mathematics is not a bag of tricks.</td>
<td>1 (1.742) *</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

II. Learning mathematics

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Not Sure</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. For students to get better at math, they need to practice a lot.</td>
<td>1</td>
<td>2</td>
<td>3 (2.258) *</td>
</tr>
<tr>
<td>8. If middle school students use calculators, they won't learn the math they need to know.</td>
<td>1</td>
<td>2</td>
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<tr>
<td>9. If students get into arguments about ideas or procedures in math class, it can interfere with their learning of mathematics.</td>
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<td>10. In learning math, students must master topics and skills at one level before going on.</td>
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<td>11. Once students can reason abstractly, the use of models and other visual aids becomes less necessary.</td>
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<tr>
<td>12. How you get an answer is as important as whether the answer is right or wrong.</td>
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<td>3 (1.968) *</td>
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</table>
13. Average mathematics students, with a little guidance, should be able to discover the basic ideas of mathematics for themselves.

14. The teacher should consistently use activities which require original thinking.

III. Teaching Mathematics

15. If a student asks a question in math, the teacher should know the answer.

16. Being personally good at mathematical problem solving has little to do with being a good math teacher.

17. Basic computational skill and a lot of patience are sufficient for teaching middle school math.

18. Students should never leave math class feeling confused or stuck.

19. Teachers should not necessarily answer students' questions but should let them puzzle things out themselves.

20. The most important issue is not whether the answer to any math problem is correct, but whether students can explain their answers.

21. Teachers should follow the math textbook that is used in their school.

22. Teachers should spend most of each class period explaining how to work specific problems.

23. Students working in cooperative groups can learn just as well as from whole class instruction.
IV. Estimate the percentage of total class time that you spend on the following: (0% - 100%)

5____ activities using manipulative models.
5____ calculator/computer activities.
10____ students working together in small groups.
15____ going over homework assignments.
10____ student explanations of their work.
15____ students working independently at their seats.
15____ teacher explanations of new material.
25____ guided practice activities.
APPENDIX C

KATHY'S SURVEY RESPONSES

Dear Colleague:

I would greatly appreciate your assistance in completing this survey. I will also be asking you to complete a similar instrument at or near the close of the 1992-93 school year. The information that you provide will be strictly confidential.

Please place your name on the line below. When I encode the completed surveys, I will assign a number to your survey and detach the cover sheet. The cover sheets and the surveys will then be stored in different files.

Tom Edwards

Your Name: ______ Kathy's responses, April 1993
Cohort group mean responses in parentheses (n=31).
Beliefs About Mathematics

Instructions: Indicate your agreement or disagreement with each statement below by circling the number that best reflects your belief.

I. Your views about mathematics

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Not Sure</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3 (4.419)</td>
</tr>
<tr>
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<td>6</td>
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II. Learning mathematics

<table>
<thead>
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<th>Strongly Disagree</th>
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<td>3</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
13. Average mathematics students, with a little guidance, should be able to discover the basic ideas of mathematics for themselves.

14. The teacher should consistently use activities which require original thinking.

III. Teaching Mathematics

15. If a student asks a question in math, the teacher should know the answer.

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7.5 going over homework assignments.
7.5 student explanations of their work.
20 students working independently at their seats.
25 teacher explanations of new material.
20 guided practice activities.
APPENDIX D

TEACHER BELIEFS SURVEY ANALYSIS - JUNE 1992

Table 4: Summary Statistics By Question

<table>
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| **QUESTION TM20:** |
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| **QUESTION TM21:** |
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| **QUESTION TM22:** |
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| **QUESTION TM23:** |
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APPENDIX E

INTERVIEW GUIDES - PILOT STUDY

Guide - First Interview

1. Background:

How long have you been a teacher?

Where did you go to school? (Elementary, H.S., College)

Tell me what your math education was like in elementary school... high school... college.

Tell me how you decided to become a teacher?

Why a math teacher?

2. Teaching:

Tell me about your first year of teaching in contrast with last year. (Similarities? Differences?)

What do you see as characteristics of a good math teacher?

How should a math teacher plan and organize his/her instruction on a long-term basis?... short term? (To get at belief regarding, "Teachers should follow text.")

3. Learning:

How do you feel about students using calculators in mathematics? What about computers?

What do you think that it takes to be successful in math?

4. Amplification of Atypical Survey Responses: (After referring to the survey, ask the following.)

You indicated strong agreement with the statement that the teacher should consistently use activities which require original thinking.

Can you give me some examples of such activities?
Could you tell me why you see this as being important?

You also indicated strong agreement with the statement that the most important issue is not whether the answer to any math problem is correct, but whether students can explain their answers.

Why do you believe that it is important that students be able to explain their answers?

Can you tell me some ways that a teacher might use to determine if students can do this?

You indicated strong disagreement with the idea that teachers should spend most of each class period explaining how to work specific problems. I'd like you to expand on your answer a bit.

Why do you strongly disagree with that idea?

What sorts of activity should the teacher engage in?

You indicated disagreement with the idea that students working in small groups can learn just as well as from whole class instruction.

Could you tell me why you feel that way?

Guide - Second Interview

1. I noticed that your journal writings for week one (9/20/92) indicated that you were still excited about TM [Transition Mathematics].

   Is the excitement still there? Why (not)?

2. During my last visit and from reading your journal, I sense a certain amount of frustration on your part.

   If that's accurate, could you tell me about it?

   During my last visit you were quite concerned about your students' ability to read the textbook.

   How is that going now?

3. I noticed in reading your journal reflections that during both the first and second weeks of UCSMP you mentioned that it was similar to your first year of teaching.

   Could you elaborate on that a bit. (In what ways?)
How do you feel now, in comparison?

4. How are your students doing, at this point?

5. Do they find the UCSMP materials any more or less interesting than other materials you've used in the past?

   Why do you think this is so?

6. How do you find teaching with the UCSMP materials, compared to what you have used/done in the past?

7. Have you been able to use any of the ancillary UCSMP materials?

   Which ones, and how did you use them?

8. In our first interview, you said that you thought that process was more important than answers in mathematics.

   Do you see such a philosophy in UCSMP? In what way(s)?

9. If you see any advantages to using the UCSMP materials, what are they?

10. If you see any obstacles to teaching with the UCSMP materials, what are they?

11. Have you been able to attend the in-service meetings that Sue Reeder has arranged for UCSMP?

    In what way(s) have they been helpful?

    Do you see any way(s) in which they might be improved?

Guide - Third Interview

1. On my previous visits, you have been concerned with your students' reading and comprehension.

   How have they been doing with the reading since my last visit in November?

   What sorts of reading strategies have you tried with them?

2. In November you were very concerned about the lack of response to the homework among your TM students.

   How are they responding now?
Is the response better, the same, or worse? If not the same, in what way(s) has it changed?  
What strategies have you used to attack their indifference to the homework?

3. What sorts of resources have you used in looking for effective strategies with which to attack these two problems (reading difficulties, indifference to homework)?

Which of these have been the most helpful?

In what way(s) have they been helpful?

4. Tell me about the UCSMP in-service meetings that you have attended since November. (What was the agenda? How were they helpful? How might they have been improved?)

5. In November, you indicated that you had registered for a District in-service on cooperative learning.

Were you able to attend? Tell me about it.

How do you see this in-service as helpful in your own practice?

6. In what way(s) will you implement some of the aspects of cooperative learning that were covered in the in-service?

7. In November, I observed a very nice lesson in your period 1 Math 7 in which, as you said, you "used what they already knew" to develop the lesson. You mentioned that it was the first time you had done so.

I'm wondering whether you meant the first time ever, or just the first time for that topic area (solution of one-step linear equations)?

8. Have you been able to do any more of that (use what they already know to develop the lesson)?

9. Tell me about those lessons.

10. Have you ever used the calculators in Math 7?  

In what ways?/How do you think they might be used in those classes?

11. In November when I observed, the TM classes were working on Chapter 3. Since the topic of the chapter was measurement, the students did not have access to the calculators.

How are the decisions when and if to use the calculators for a particular lesson made?

Do the students share in this decision?
12. Now that you are nearly at the half-way point, give me your thoughts on the UCSMP/TM curriculum.

Guide - Fourth Interview

1. How has the reading been going?
   Do they now read mostly in class or at home?
   How is their comprehension?

2. The last time you said that you really liked the way the book connected ideas and that your students seemed to be making some of these connections.
   Do you still feel that way?
   What sorts of connections have your students been making?
   How has this helped them?
   Has it helped their reading comprehension?
   In what ways?

3. On the video tape that you made for me and in my observations of your work, I have noticed that you seem to try to provide students with conceptual explanations of mathematics.
   Is this a valid observation on my part?
   Do you ever ask students to provide such conceptual explanations?
   For example? (Why not?)

4. I have noticed that you frequently ask students to put their bellwork or homework solutions on the board. When I have seen this, I notice that you usually explain the work.
   Do you ever ask the kids to explain the work they have put on the board?
   Would there be any benefit to doing so?

5. Sometimes I sense a tension in your work between procedural knowledge and conceptual understanding. Have you been conscious of any such tension?
   If so, could you guess at the source(s) of that tension?
   Which do you feel is more important for students to have?
6. Do you sense any tension between what I'll call the UCSMP style and your own tendency to operate a fairly structured classroom?
   If so, in what way(s)?

7. What sources do you use for your bellwork questions in TM?
   ... in Math 7?

8. In your Jan. 8 journal, you might recall writing that it didn't feel like you were doing much compared to the past when you used a more teacher-centered lecture type format.
   Does it still feel like that?
   Can you describe what it is that you do (or don't do) that's different?

9. In that same journal, you said that you were beginning to appreciate your students' abilities and were somewhat surprised by their actual capabilities.
   Do they continue to surprise you?
   In what ways?
   If they no longer surprise you, are you still able to appreciate their abilities?
   What do they do that's different?

10. You said last time that the kids were starting to ask some "insightful" questions.
    Do they continue to do so?
    Can you give me some examples?

11. Have you been able to do anything more with a cooperative group structure?

12. Tell me about the inservices:
    a. UCSMP
    b. Coop. learning

13. The last time you seemed to be feeling better about the UCSMP curriculum and that you were making some progress with it.
    How do you feel about these issues today?

14. Could you describe any effect(s) that using the UCSMP curriculum might have had on your work?
Guide - Fifth Interview

1. The last time I was here, I neglected to ask you about the cooperative learning inservice meetings.

   Could you tell me what you remember of them from perhaps the first of the year?

2. From what I have seen and read in your journal, you have used cooperative learning groups for review lessons.

   Is there a place for group work in lessons where you are developing concepts?
   Could you expand on that a bit?

3. I'd like you to think back to earlier in the year when you first developed an interest in learning more about, and using, cooperative learning groups.

   Can you tell me what sparked that interest in the first place?

   Were there any other influences that kept that initial interest alive?

4. In our last interview, we discussed students' understandings of mathematics.

   Could you tell me what you believe it means for a student to "understand" a mathematical topic?

   We have talked in the past about students understandings of concepts versus procedures.

   What are some of the ways that a teacher can help 7th & 8th grade students develop a conceptual understanding.

5. Let me describe one aspect of two hypothetical teachers to you: Teacher A asks a lot of questions to help students to see the meaning of mathematical concepts, as Teacher A understands them. Teacher B also asks a lot of questions to help students build their own meaning of mathematical concepts.

   Could you tell me which of these two approaches you see as being closer to an ideal?

   Why do you believe that?

   Where do you see yourself in relationship to teacher A and teacher B?

6. Tell me how you have been handling the reading.

   Have the kids been doing more reading on their own?
7. Have the kids continued to improve in their homework preparation?
   Is the quality any better?

8. Has the behavior of your TM students continued to be better than it was before
   the shift to morning classes?
   How do you see this as impacting on your planning?

9. The past couple of times I have been here, you have mentioned connections that
   the kids and you have been making among various mathematical topics.
   Have the students continued to make such connections?
   Have you been likewise making some connections that in the past you perhaps
   did not?
   I believe that I know the answer to this, but would you tell me again what you
   see as the source of these connections?

10. Last time I asked if you saw any ways in which the UCSMP text and materials
    had influenced what you do in the classroom.
    Can you think of any such ways today, perhaps in addition to those you
    mentioned last time?

11. You might recall that my primary interest is on teacher change: how teachers
    change their practice, influences that precipitate such changes, and things that
    constrain such changes.
    Can you think of anything that has impacted on your practice this year in any
    of these areas that we have not discussed?

Guide - Sixth Interview

1. When I was here in March, I noticed that you sometimes let student responses
   stand on their own merits without passing judgment on them yourself, while
   other times, you would make it a point to say things like, "Good," or "Correct,"
   or some such. Were you aware of this dichotomy?
   What do you think about letting students themselves, as a group, decide on the
   merits of each other's responses?

2. Where should the authority for correctness lie?
   Could the class as a mathematical community play that role?
Why/why not?

3. Tell me what you have been able to do with cooperative groups since my last visit.

4. Tell me about the inservice meetings since March.

5. Were you able to respond in your journal entries to my three questions from last time?
   a. What does it mean for a student to understand something in mathematics?
   b. How has UCSMP influenced what you do in the classroom?
   c. What things have influenced/constrained changes in what you do in the classroom?

6. In our informal conversation last time, I believe that you mentioned reading an article in *JRME*. How often do you read *JRME*?

   Why do you read it?

   What is your opinion of the articles that you have read in *JRME*?

7. I'm going to share about a half-dozen interpretations of what I have seen, heard, and read of your practice this year. I'd like you to do two things, if you can. First, tell me if you agree or disagree with my interpretation. Next, try to give me some amplification: "Yes, I agree with that, because ...," or "No, I don't think so, because ..." I'll use your pseudonym, "Diane," throughout.

   a. Diane is a teacher who was disposed to change at the beginning of the school year.
   b. Much of what Diane does in the classroom is done for management considerations.
   c. There is a developing tension in Diane's practice between the need for her students' conceptual understanding and their procedural understanding. This tension is not yet resolved.
   d. Diane is possibly beginning a transition from all teacher imposed meanings to some negotiation of taken-as-shared meanings.
   e. There is an ongoing development of mathematical connections in both Diane and her students, and the UCSMP text seems to be both a source and a catalyst in the process.
   f. The UCSMP curriculum has been both an agent of, and a constraint to, changes in Diane's practice.
Suspected missing page 186.


Suspected missing page 193.
LIST OF REFERENCES


