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METHODS COURSES AND FIELD EXPERIENCES INFLUENCES ON PRESERVICE SECONDARY MATHEMATICS TEACHERS' BELIEFS ABOUT THEIR ROLE IN MATHEMATICS CLASSROOM DISCUSSION: FOUR CASE STUDIES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of the Ohio State University

By

Martin Dirk Hartog, B.A., M.S.

* * * * *

The Ohio State University

1995

Dissertation Committee:

Alan Osborne
Josué Cruz
Patricia A. Brosnan

Approved by

Advisor
Educational Theory and Practice
Preservice teachers enter mathematics education programs having formulated beliefs about their role as a teacher largely based on the long hours they have spent in the classroom as learners. When mathematics methods courses recommend techniques, such as the student-centered mathematics instruction proposed by the National Council of Teachers of Mathematics (NCTM) in the *Curriculum and Evaluation Standards for School Mathematics* and the *Professional Teaching Standards for School Mathematics (Standards)*, preservice teachers' beliefs are challenged and possibly changed. This study examined the incoming beliefs of four preservice secondary mathematics teachers about their role in discussions in the mathematics class and the changes in those beliefs that resulted from their participation in a mathematics methods class and related field experiences during the first two quarters of their program. Data included interviews upon entering the program and at the end of each quarter; entries in weekly journals kept by the preservice teachers about their field experiences; interviews with the cooperating teachers, university supervisors,
and methods course instructors; observations of methods class instruction; and observations of the preservice teachers while teaching.

Results documented that preservice teachers enter the teacher education program with preconceived beliefs about their role as teachers in discussions, but that these beliefs do not necessarily reflect the methods employed by their previous teachers. Exposure to teaching methods recommended by the NCTM Standards during the methods class affect changes in the preservice teachers' expressed beliefs about their role in conducting discussions. Specifically, it affected their use of questioning, wait time, and tasks to promote discussion, such as the use of manipulatives, problem solving, and cooperative groups. However, the preservice teachers' behavior did not reflect those changes without the support of cooperating teachers and university supervisors who identify and help modify behaviors inconsistent with the preservice teachers' expressed beliefs.
ACKNOWLEDGMENTS

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clearinghouse's resources available to me; to my church family whose support and prayers helped me each step of the journey; and to a faithful God who answered those prayers.
VITA

February 20, 1950 .......................... Born - Mt. Vernon, New York

1972  .................................... B.A., Iona College
                                        New Rochelle, New York

1974  .................................... M.S., University of Wisconsin -
                                        Milwaukee

1974-1978  ................................ Mathematics Teacher,
                                 Ridgefield High School,
                                 Ridgefield, Connecticut

1978-1989  ................................ Mathematics Teacher,
                                 General Board of Global
                                 Ministries, Mulungwishi and
                                 Kapanga, Zaire

1989-1992  ................................ Graduate Teaching Assistant,
                                 Department of Mathematics,
                                 The Ohio State University,
                                 Columbus, Ohio

1992-1994  ................................ Graduate Research Assistant,
                                 Mathematics Education Analyst,
                                 ERIC Clearinghouse for
                                 Science, Mathematics, and
                                 Environmental Education,
                                 The Ohio State University,
                                 Columbus, Ohio

1994-Present  .............................. Assistant Professor
                                 Mathematics Department
                                 Southern Connecticut State
                                 University
FIELDS OF STUDY

Major Field: Educational Theory and Practice

With a Concentration in Teacher Education
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CHAPTER I
INTRODUCTION

"The discourse of a classroom--the ways of representing, thinking, talking, agreeing and disagreeing--is central to what students learn about mathematics as a domain of human inquiry with characteristic ways of knowing. Discourse is both the way ideas are exchanged and what the ideas entail: Who talks? About what? In what ways? What do people write, what do they record and why? What questions are important? How do ideas change? Whose ideas and ways of thinking are valued? Who determines when to end a discussion? The discourse is shaped by the tasks in which students engage and the nature of the learning environment; it also influences them."
(National Council of Teachers of Mathematics, 1992, Professional Standards for Teaching Mathematics)

These words from the National Council of Teachers of Mathematics indicate that discourse is central to the way in which students learn mathematics and learn to express themselves mathematically. The exchanges that take place between teacher and student, between teacher and students, and between student and student shape the way students perceive mathematics. However, who shapes the teachers? They are a product of
their own experiences as students, their experiences in teacher education programs, and their experiences once they enter the classroom. If these experiences are harmonious, the teacher will likely create a classroom environment that reflects those experiences. However, what if the experiences conflict? How will the teacher resolve that conflict? Students entering the mathematics teacher education program today may well face that conflict. The Professional Standards for Teaching Mathematics are recommending a departure from teaching practice that most students entering the mathematics teacher education program will have seen. Teacher education programs are being asked to promote these standards as the appropriate methods for teachers to employ (NCTM, 1992; Leitzel, 1991). How will the discrepancies between experiences as a student and the recommended practices of the teacher education program affect the way that preservice teachers perceive their role in the discussions that will take place in their classrooms?

A. Background.

A primary objective of teacher education programs is to prepare preservice and inservice teachers with adequate competencies to enable them to function and grow in the teaching profession. Since the inception of mass education, debate has ensued concerning the most effective methods of teaching mathematics. The debate has been characterized by the many reform movements that have attempted to change the face of mathematics education. Among these reforms were the progressive movement led by John Dewey in the early part of the century, the modern math reforms of the early 1960s, the back to basics movement of the 1970s, and the focus on
problem solving that emerged in the early 1980s. The latest in this chain of proposed movements followed reports in the middle 1980s stating that mathematics achievement in the United States had remained low despite all these reform efforts, and that through the years students were becoming progressively more ill-equipped to face the demands of today's job market. *A Nation at Risk* (National Commission for Excellence in Education, 1983) brought the low levels of academic achievement, in general, and in mathematics, in particular, in United States' schools to the attention of the lay public.

The mathematics education community had anticipated this problem by the publication of *Agenda for Action* (National Council of Teachers of Mathematics, 1980). *Agenda for Action* promoted a mathematics classroom in which problem solving would be a focal point of the learning experience. The development of problem-solving abilities would be facilitated by introducing technology use in the classroom in the form of computers and calculators, enabling teachers to move away from an overemphasis on pencil-and-paper skills.

The climax of this movement came when the National Council of Teachers of Mathematics (NCTM) published two sets of standards for mathematics education, the *Curriculum and Evaluation Standards for School Mathematics (Standards)* (NCTM, 1989) and the *Professional Teaching Standards for School Mathematics (Teaching Standards)* (NCTM, 1991). (Henceforth, use of Standards will refer collectively to both documents.) The Standards provided a vision of the mathematics curriculum that would enable students to build mathematical power. Mathematical power is the ability to reason, problem solve, and communicate mathematically. The
*Standards* emphasized a change in the teacher's role and different techniques in evaluation in mathematics education. The development of curriculum standards necessitated a shift in the basic methods of teaching in the majority of mathematics classrooms today. The *Standards* proposed a shift from a teacher-centered/transmission model of instruction to a student-centered/constructivist model.

The shift of the teaching paradigm suggested by the *Standards* is the major impetus for this study. How will students who have chosen to become mathematics teachers respond to the suggested methods of the *Standards*, if they have been taught mathematics with methods that reflect the approach that the *Standards* wish to change?

**B. Teacher-Centered/Transmission Approach.**

The teacher-centered/transmission approach to teaching mathematics is the most widely used method of teaching in the United States. It is based on a view of mathematics referred to as the instrumentalist view. In this perspective, mathematics is thought of as a collection of facts, rules, skills, and processes that are to be mastered by the student and demonstrated in test and classroom situations. The role of the teacher in a classroom that takes this approach is to demonstrate the desired skills with adequate explanations so that students will become proficient in their reproduction. The role of the student is to listen, assimilate ideas, and solve problems as modeled by the teacher.

A standard instructional routine in mathematics classes has been identified by mathematics education experts and nonspecialists alike (Goodlad, 1984). The routine consists of the teacher: (1) going over the
previous days homework to demonstrate mastery of a skill; (2) introducing
the next of a sequential set of skills and procedures to be mastered; and (3)
allotting time to start the next day's homework. Despite the criticism that has
been directed at this approach (Welch, 1978; National Commission of Teacher
Excellence, 1983), the approach continues to dominate the scene of our
nation's mathematics classrooms.

The most recent National Assessment of Educational Progress (1990)
collected data from both teachers and students on instructional practices
found in the classrooms. The results indicated that more than the majority of
all assignments for fourth, eighth, and twelfth graders came from the
textbooks. Only one-third of the students across all three grade levels
reported learning mathematics via small-group instruction or using
manipulatives, lending credence to the fact that the instrumentalist view of
mathematics still dominates the classroom today.
C. Student-Centered/Constructivist Approach.

In contrast to the teacher-centered/transmission approach is the student-centered/constructivist approach. Knowledge formation is no longer the transmission of facts and procedures, but rather a process in which individual learners build and refine their cognitive structures, their knowledge of the world, in order to better interpret their world. This approach is related to a problem-solving view of mathematics that Ernest summarized as:

"a continually expanding field of human creation and invention, in which patterns are generated and then distilled into knowledge. Thus mathematics is a process of inquiry and coming to know, adding to the sum of knowledge. (1988, p.10)

This view of mathematics goes hand-in-hand with the constructivist approach to learning in which students come to know mathematics through a process of assimilating or accommodating mathematical concepts as they arise in problem situations. Underlying this perspective are the following assumptions:

- Knowledge is actively created or invented, not passively received.
- Children create new mathematical knowledge by reflecting on their physical and mental actions and integrating new ideas into their preexisting structures of knowledge.
- Learning mathematics is a process of adapting to and organizing one's quantitative world.
- Learning mathematics is a social process in which mathematical ideas are established cooperatively by members of a classroom culture through discourse involving explanation, negotiation, and evaluation.
- Sense-making is curtailed in students when teachers demand that students use specific mathematical methods, creating the view that mathematics is a set of procedures to be mastered. (Clements & Battista, 1990)
This perspective is the approach advocated by the National Council of Teachers of Mathematics (NCTM), as proposed in the Standards (1989, 1991). The assumptions for a constructivist approach are embodied in the Standards as summarized in the National Research Council's (NRC) Everybody Counts (1989):

Effective teachers are those who can stimulate students to learn mathematics. Educational research offers compelling evidence that students learn mathematics well only when they construct their own mathematical understanding. To understand what they learn, they must enact for themselves verbs that permeate the mathematics curriculum: "examine," "represent," "transform," "solve," "apply," "prove," "communicate." This happens most readily when students work in groups, engage in discussion, make presentations, and in other ways take charge of their own learning. (p.58-59)

Classrooms engaged in mathematics learning from a constructivist approach will exhibit different characteristics from those engaged in mathematics learning form a transmission approach. The verbs used to describe the learning in a constructivist classroom; examine, represent, transform, solve, apply, prove, communicate; imply a change in the nature and quality of the discussions that presently take place in the classroom. Students will not be passive receivers of knowledge, but active participants in learning.

D. Change in Mathematics Teaching.

If these changes in the way students learn are to occur, there will need to be corresponding changes in the way mathematics is taught (NRC, 1989; NCTM, 1989; Wood, Cobb, & Yackel, 1990). The Standards identified five major shifts that are needed to move current practice toward the vision of the Standards:
1. toward classrooms as mathematical communities-away from classrooms as simply a collection of individuals;

2. toward logic and mathematical evidence as verification-away from the teacher as the sole authority for right answers;

3. toward mathematical reasoning-away from merely memorizing procedures;

4. toward conjecturing, inventing, and problem solving-away from an emphasis on mechanistic answer-finding; and

5. toward connecting mathematics, its ideas, and its applications-away from treating mathematics as a body of isolated concepts and procedures. (p.3)

How these shifts take place is a major concern of the mathematics education community. Several factors that influence teacher practice have been identified: content knowledge, pedagogical content knowledge, teachers beliefs about mathematics, and teachers beliefs about the teaching of mathematics (Shulman, 1987; Ball, 1988; Thompson, 1984). The focus of this study will be on the beliefs component that affects teachers' behavior in the classroom.

E. Teachers' Beliefs Influence Teaching Methods.

The changes envisioned by the Standards (1989) and Teaching Standards (1991) will not occur simply because they have been identified and communicated by the National Council of Teachers of Mathematics (Crawford, 1990; Shaw & Jakubowski, 1990; Olson, 1981; Ball, 1990). Many factors contribute to the implementation of proposed curricular and teaching reforms. One factor that has been receiving greater attention in recent years is the teachers' beliefs about the content to be taught and the methods of teaching that content.
Research reveals that beliefs do influence the teacher's behavior in the classroom (Thompson, 1984; Cooney 1985; Wood, Cobb, & Yackel, 1991; Scheding 1981; Peterson, Fennema, Carpenter, & Loef, 1989). Working from these findings, if current practice needs to be changed, a corresponding change in teachers' beliefs toward teaching mathematics will need to occur (Shaw, 1991; Wood, Cobb, & Yackel, 1991; Ball, 1991). The beliefs of prospective teachers also must be considered. Although preservice teachers have not had the years of classroom practice that solidify beliefs about teaching, they do come to the teacher education program with more that 15 years experience in the educational system as students. Lortie (1975) refers to this time as the "apprenticeship of observation", during which the intuitive foundations of the preservice teachers' beliefs about teaching and learning are formulated. The documented evidence that the teacher-centered/transmission approach to teaching is the predominant teaching perspective in the classroom indicates perspective teachers are likely to enter the teacher education program with beliefs that need to be changed.

Research has investigated practicing teachers beliefs toward teaching and ways in which those beliefs can be changed to reflect desired reforms (Ball, 1990; Lappan, 1986; Collier, 1972; Helms, 1989; Cronin-Jones & Shaw, 1992). Research has also examined the beliefs of preservice teachers and how those changes in these beliefs occur (Ball, 1988; Scheding, 1983; Schram et al, 1988 & 1991). These studies have examined beliefs about the nature of mathematics and beliefs about mathematics teaching in general.

Logical next steps are to examine beliefs about particular aspects of mathematics teaching. Among them are three categories of teachers' content knowledge--Subject Content Knowledge, Pedagogical Content Knowledge,
and Curricular Content Knowledge—as identified by Shulman (1986); assigning tasks to promote mathematical understanding; creating a classroom environment in which students are safe to explore mathematical content; and the teacher's role in conducting discussions in the mathematics classroom. This study is designed to focus on the beliefs about communications in the mathematics classroom and the stability of those beliefs during student participation in methods classes and field experiences.

F. Discussion in the Mathematics Classroom.

The dimensions of the teachers' role are varied and complex (Cruickshank, 1989; Heck; 1981). One dimension of the teachers' role that is universal is the decision of how discussions will take place in the classroom. Throughout this study, the term "discussion" will refer to the exchange of meaningful verbal communications intended to facilitate the learning of mathematical concepts. Whereas, not all aspects of the teacher's role in the classroom will change as a result of the reforms encouraged by the Standards, the teacher's role in classroom discussions should necessarily change. The teacher should no longer be a transmitter of information in a lecture mode to passive learners, but should rather be an orchestrator of discussion, responsible for creating a classroom environment in which students freely explore mathematical concepts, individually and cooperatively, in a sense-making experience.

The Standards present an overall view of what that classroom will look like in the six standards that have been formulated for teaching. Of the six teaching standards, three refer directly to "discourse." Discourse is defined as "the ways of representing, thinking, talking, agreeing, and disagreeing about mathematics." Standards 2-4 address the teacher's role in discourse,
the student's role in discourse, and tools that enhance discourse. Two other standards speak indirectly to discourse by addressing the tasks assigned by the teachers that promote discourse and create a classroom environment that gives students the opportunity to contribute freely to discourse.

Hyman and Whitford (1990) offer eight discussion tactics for content area teaching that fit closely to the discussion in the mathematics classroom as presented by the Standards. The eight tactics are: priming the pump, accepting, probing, using wait time, focusing, energizing, referring to previous student remarks, and launching. Priming the pump involves actions that draw students into the discussion. By "accepting" students' ideas, teachers create an environment that encourages students to contribute their ideas to the discussion in a safe manner. "Probing" encourages the student to think more deeply about the topic of discussion. In "focusing," the teacher keeps the discussion focused on the intended topic, while keeping in touch with the students' contributions to the discussion. "Waiting" is the tactic in which the teacher pauses a significant amount of time, both in anticipating a student's response and in responding to a student's contribution. The teacher "energizes" a discussion by breaking up into smaller groups in order to address specific issues related to the topic. The teacher can "refer back to previous comments" to refocus the students and continue the planned line of questioning. "Launching" involves questions that will summarize the results of the discussion.

Classroom discussions have been categorized in several different ways. Dillon (1984), in an analysis of research on questioning and discussion, distinguished between lecturing, recitation, and discussion. Lecturing involved teacher transmission of information. Recitation involved
teacher/student interactions that could take the form of drill, review, quizzing, guided discovery, inquiry teaching, or the Socratic method. This is differentiated between discussion involving student/student interactions. Several different taxonomies have been proposed for discussions (Hyman and Whitford, 1990; Gall, 1984; Roby, 1981), all of which include problem solving as one of the formats. Goodlad (1984) reported finding discussions taking place in only 4-8% of the classrooms that he studied.

Preservice teachers have had direct experiences in participating in discussions and will, most likely, hold formulated beliefs about how discussion should enfold (Lortie, 1975). Based on reports already cited on current practices in the mathematics classroom, preservice teachers experiences and corresponding beliefs will likely not reflect the practices advocated in the *Teaching Standards*. Teacher education programs have the task of preparing teachers to function in the classroom and advocate methods of effective practice as established by the mathematics education community; i.e. the methods proposed in the *Standards*. As a result of this apparent conflict, students' beliefs will be challenged and subject to change. Will those changes take place and, if so, what will be the catalysts that promote those changes?

**G. Research Questions.**

This study examined what effects the participation in a teacher education program had on the beliefs of preservice secondary mathematics teachers about their role in mathematics classroom discussion in comparison to the NCTM *Standards*. To investigate the development of those beliefs, case studies of a sample from a cohort of juniors entering the mathematics
education program for secondary school teachers at a major land-grant university in the Midwest was compiled. The cohort of 14 students considered for the study consisted of 5 males and 9 females. The two-year program included a mathematics methods course, foundational courses in learning and teaching, mathematics courses, field experiences during the junior and senior years, two philosophy of education courses, and secondary school student teaching. Since the junior field experience progresses from the elementary school to the junior high school, and then to the senior high school in successive quarters, and the mathematics methods course is offered in the autumn quarter of the junior year, the case will be developed over the autumn and winter quarters of the junior year to allow the investigator to identify incoming beliefs towards the teacher's role in discussion, expressed belief changes, and how those changes, if present, might affect teaching practice.

With this intention, the following research questions have been formulated:

1. What experiences in mathematics classroom discussion do preservice secondary mathematics teachers bring to the teacher education program?

2. Can these experiences be used to classify preservice secondary mathematics teachers' beliefs toward their role in mathematics classroom discussion?

3. Do preservice secondary mathematics teachers expressed beliefs toward their role in mathematics classroom discussion change as a result of their participation in methods courses and field experience during their first two quarters in the teacher education program?

4. What factors contribute to that change, if exhibited?
5. Are expressed beliefs consistent with the way that preservice secondary mathematics teachers attempt to conduct discussion in their field experiences?
CHAPTER II
LITERATURE REVIEW

This literature review examines studies of interactions and relationships among preservice secondary mathematics teachers learning experiences, participation in teacher education courses, and beliefs about the teacher's role in the mathematics classroom discussion. In a model for the integration of the knowledge, beliefs, and attitudes of the mathematics teacher, Ernest (1989) distinguished between two aspects of the psychology of teaching: (a) the thought processes that include planning, interactive decision making and reflection and (b) the thought structures of the teacher that include knowledge, beliefs, and attitudes. Although a substantial volume of research has been conducted on the teacher's thought processes (Wittrock, 1986; Porter and Brophy, 1988), development in cognitive psychology has generated interest in the cognitive structures of the teacher.

The research model in Figure 1 (Koehler & Grouws, 1992) illustrates different factors that influence a teacher's behavior. Three of the factors identified are those stated by Ernest as the thought structures of the teacher, with beliefs as one of the components contributing to teacher practice.
This component is broken up into two parts, beliefs about teaching mathematics and mathematics itself. Medley's model for research in teacher education (Cruickshank, 1990, p. 8) in Figure 2 indicates how the prior experiences and teacher education courses also influences teacher competencies. Pre-existing teacher characteristics include beliefs about the teacher's role in conducting discussions. This coupled with the instruction received in the teacher education program would determine the teacher's behavior in the classroom.
Figure 2. Medley's model for research in teacher education.

Bringing these components together provides the theoretical framework to study the origins and development of preservice secondary mathematics teachers' beliefs about their role in classroom discussion.

It is beyond the scope of this study to review the entire literature on teacher behavior. Comprehensive reviews have been done by Rosenshine and Furst (1971), Dunkin and Biddle (1974), Wittrock (1986), and Cruickshank (1990) concerning teaching and learning behaviors and will not be duplicated here. This review is restricted to the literature involving the variables identified by the above models related to the research questions of the study.
Beliefs

Several definitions have been proposed to clarify the meaning and usage of the term beliefs. Hart (1989) attempted to clarify the different uses by mathematics educators and cognitive psychologists of different terms when discussing the affective domain. Distinctions between attitude and beliefs offer a constant source of confusion. Psychologists generally define attitude as "a predisposition to respond in a favorable or unfavorable way with respect to a given object (i.e. person, activity, idea, etc.)" (Hart, 1989, p.39). When creating items to assess attitudes, Mueller (1989) assigned the attitude items into three categories: (a) an emotional reaction to the object (affective), (b) beliefs about the object (cognitive), and (c) behavior toward the object (conative). Note that in this scheme, beliefs are expressed as the cognitive component in a person's attitude toward the object, reinforcing the close link between attitudes and beliefs. Beliefs have been defined by Colby as a judgement of the "credibility of a conceptualization" (1973, p.253). This would coincide with Fishbein and Ajzen (1975) who define belief about an object as "the subjective probability of the relation between the object of the belief and some other object, value, concept, or attribute" (p.131). Good (1973) defines belief as the acceptance of a proposition as true or of a situation or object as actually existing.

Individual beliefs are related to the notion of belief systems. Just as single concepts fit into a schema, beliefs fit into belief systems. This metaphor is employed to examine how the ways in which beliefs interact can be organized with respect to one another. Green (1971) identified three dimensions of belief systems that correspond to: (a) interconnectedness of beliefs in a quasi-logical structure, (b) the degree of conviction with which
beliefs are held, and (c) the structuring of beliefs in clusters. Recognizing that beliefs are related in some structure helps to understand the relationship between beliefs and behaviors. It is not always true that expressed beliefs are consistent with exhibited behavior (Cooney, 1985). Inconsistencies can occur when beliefs are held in isolation of one another. However, when beliefs are modified to resolve or avoid inconsistencies, the system becomes apparently coherent (Thompson, 1992).

For the purpose of this study, the object of belief will be the role of the mathematics teacher in classroom discussion. The definition of beliefs used states that beliefs reflect "certain types of judgements about a set of concepts" (Hart; 1990; p.40).

Beliefs Toward Mathematics and Mathematics Teaching

Beliefs about mathematics and teaching mathematics have been the objects of numerous studies. These studies usually concentrate on that part of Koehler and Grouws' (1992) or Medley's (1982) theoretical models that link teachers beliefs to teacher behavior. The studies can be separated by the populations of the study; preservice or inservice teachers.

Zeichner and Gore's (1990) review of research on the teacher socialization process indicated that one approach to the topic is based on Lortie's (1975) assertion that preservice teachers enter teacher education programs with preconceptions of their roles in teaching. This assertion was based on previous studies in which teachers attested to the strong influence of earlier mentors compared to the instruction received during their formal training. More recent research has supported the argument for this approach. Crow studied preservice teachers in a secondary education group to "investigate the context of socialization and describe the interaction of
elements which constitute the socialization process of preservice teacher into the profession" (1987, p.2). Crow found that each student entered the program with established images of themselves as teachers developed on both positive and negative role models of former teachers.

A second aspect of what preservice teachers bring to the teacher education program involves their beliefs about mathematics and teaching mathematics (Collier, 1972; Bolling, 1976; Scheding, 1981; Ball, 1988; Helms, 1989). Shulman's (1986) emphasis of the need to include the context of subject matter in research on teaching and learning to teach coincided with studies that focused on preservice teachers' beliefs about mathematical content knowledge and pedagogical content knowledge. Ball (1988) studied preservice elementary and secondary teachers with respect to their knowledge and beliefs of mathematics and mathematics pedagogy. She found that both groups had perceptions of mathematics that were rule bound and procedurally driven.

Helms' (1989) case study of two preservice secondary mathematics teachers classified the informants' beliefs about mathematics and mathematics teaching with respect to Perry's scheme of intellectual growth and Schiro's ideology of different approaches to developing a curriculum. Helms classified his informants' beliefs with respect to personal philosophies, beliefs about mathematics, and beliefs about teaching. When describing the origins of these beliefs, the informants referred to past teachers and friends, but made no reference to their teaching methods courses. This reinforces the idea that preservice teachers have significant beliefs coming into their teacher preparation programs.
Ernest (1988) studied the attitudes and practices of student teachers with respect to elementary school mathematics to see if positive attitudes toward mathematics influenced their decision to teach using an open or closed approach to teaching mathematics. Ernest compared test scores on questionnaires to assess attitudes toward mathematics and mathematics teaching with observations of their teaching approaches. He concluded that the student teachers' attitudes toward mathematics correlated less strongly with their teaching practices than their attitudes toward teaching mathematics.

Studies have focused on the relationships between beliefs about mathematics and various outcomes related to mathematics teaching of inservice teachers. Peterson, Fennema, Carpenter, & Loef (1989) examined the relationship between first-grade teachers' pedagogical content beliefs, teachers' pedagogical content knowledge, and student achievement in mathematics. Based on a framework for analyzing teachers' pedagogical beliefs, teachers' were classified as cognitively based or less cognitively based. They found students of cognitively based teachers had higher achievement.

Teachers' expressed beliefs and behaviors are not always in harmony. Crawford (1990) surveyed secondary mathematics teachers' beliefs and practices in comparison to the NCTM Standards. Based on survey responses, teachers reported high level of agreement with questions concerning the teaching of non-routine problem solving, use of cooperative small groups to discuss and develop concepts, peer teaching, and cooperative learning. However, when asked to compare their teaching to scenarios reflecting the Standards, fewer than one-third of the teachers said they would use the
scenario. Crawford concluded teachers still held beliefs that were tied to a curriculum driven by paper and pencil skills.

The issue of discrepancies between teachers' expressed beliefs and behaviors was seen in the study of a beginning teachers' expressed beliefs about mathematical problem solving and his actions (Cooney, 1985). Although the beginning teacher, Fred, attached great importance to problem solving, he compromised his instructional methods in the face of perceived conflicting demands in the classroom. Thompson (1984) studied the beliefs of three middle school teachers, but reported both consistency and inconsistancy between teachers' professed beliefs and instructional practices.

In summary, research indicates that preservice and inservice teachers' beliefs about mathematics and mathematics teaching can be categorized. How do these beliefs develop and what experiences influence change in beliefs?

**Changing Teachers' Beliefs**

As understanding of the role that a teachers' beliefs play in their teaching practices increases, the question arises as to how these beliefs are formed and how they can be affected. This question becomes more critical in light of reforms that call for change in practice. The implementation of curriculum reforms are not guaranteed by dictums made by the educational community (Ball, 1990; Olson, 1981; Osborne and Crosswhite; 1977). Changes in recommended teacher behaviors necessitate changes in beliefs systems in order to produce the harmony between beliefs and behaviors conducive to effective learning. Several studies have investigated the interactions between changes in beliefs and changes in practice. These studies can again be separated by the population studied: preservice or inservice teachers.
First, several studies have examined the impact of teacher education components on preservice teachers. Collier (1972) studied the changing beliefs of preservice elementary teachers beliefs as they progressed through their teacher education program. Results indicated only slight progress from a formal view of mathematics characterized as rigid and exact, free of ambiguity and contradiction, made up of rules and formulas, to a more informal view of mathematics characterized as creative and investigative in nature.

Ball (1988c) and McDiarmid (1990) experimented with methods class instruction that challenged preservice teachers' beliefs. Each studied the effects of having students observe lessons on negative numbers and combinatorics being taught that cognitively challenged their present beliefs. After analyzing the differences between the way in which the concepts were taught and the way in which the preservice teachers would have taught the lesson, the preservice teachers were asked to teach the concept to someone themselves. Results indicated that assenting to what was observed and replicating it in teaching was difficult for many of the preservice teachers. McDiarmid concluded that despite the ability to get the preservice teachers to reconsider their teaching, it was doubtful the effects would be long-lasting.

Cronin-Jones & Shaw (1992) studied preservice elementary and secondary science teachers to determine the influence that methods instruction had on their beliefs about instruction. They focused on early stages of their development where, according to Mayer and Goldsberry (1989), beliefs are in a state of flux. Their findings affirm the view that students do possess belief structures regarding teaching before and after methods
instruction. They recommended that beliefs be explored prior to methods class enrollment in order to tailor course instruction to the students.

Schram, Wilcox, Lappan, & Even (1988) and Schram, Wilcox, Lappan, and Lanier (1991) engaged preservice elementary teachers in learning experiences that emphasized group work and problem solving to determine if such experiences changed their beliefs about mathematics teaching. They contended that their findings "support the assertion that creating a community of learners engaged in doing mathematics can be a powerful influence in increasing teacher candidates' self-confidence as mathematical problem solvers." However, they concluded that this process can take a long time to develop and that preservice teachers' efforts to transfer similar emphases into their own classrooms can be problematic.

Second, the issue of effecting change in beliefs in order to effect change in behavior has been studied for inservice teachers. Lappan et. al. (1988) employed Lewin's model of change in beliefs that proposed that old beliefs had to be first unfrozen, changed, and then refrozen while studying the change in beliefs of inservice mathematics middle school teachers. The project envisioned a period in which teachers thought and talked about the projects' goals, the unfreezing stage. This would be followed by a period in which teachers began to incorporate new teaching strategies such as wait time, cooperative learning, and questioning into their teaching methods, the change stage. Finally, they expected to see a move from thinking about these methods to believing in them, exhibiting a comprehensive application of the methods, the refreezing stage. Exposure to a two-week summer workshop was found to be sufficient to teach the project units, but insufficient to promote transfer to other parts of the curriculum.
Inservice teachers are sometimes asked to implement curriculum changes that conflict with their existing beliefs and knowledge systems. Olson (1981) studied science teachers' inability to change their practice required by curriculum reform. He found teachers were not able to understand the recommended changes and, therefore, created personal interpretations in order to assimilate them into their own frame of reference. Ball interviewed a secondary mathematics teacher to examine the agreement between the teachers' perception of how her teaching reflected new curriculum standards and Ball's assessment of that agreement. While the teacher felt she adequately applied the proposed changes, Ball felt the teacher assimilated the language of the reform into her own practice without truly reflecting the intended reforms.

Cognitive agreement does not always produce change in teacher behavior. Briscoe (1991) argued that teachers need to have a role metaphor for the intended change, in order for the change to occur. Wood, Cobb, & Yackel (1991) did a case study of a second-grade teacher whose beliefs and practice regarding teaching mathematics were challenged as she participated in an ongoing research project based on constructivist views. Her beliefs changed from a procedural view of mathematics, passively learned, and transmitted by the teacher, to a view of mathematics that is actively learned in a community of learners guided by the teacher. By being integrally involved in the research project, the teacher was able to envision her new role and actualize it with the help of the research team.

Ball (1988b) reports on the efforts of the National Center for Research on Teacher Education to study how teacher's knowledge changes. The strategy to track teacher learning and beliefs development was developed utilizing three
instruments: (a) a questionnaire, (b) an interview, and (c) classroom observation. She concluded that this method can enable researchers to understand what people learn about a particular dimension of teaching from a variety of experiences.

These studies indicate changing beliefs about teaching mathematics is similar to learning. Just as the learner needs a willingness to change their conceptions of an object and a framework into which to make those changes, the teacher must be willing to expand their concepts of teaching into a framework that can accept those changes. This would correspond to the unfreezing stage of Lewin's model. It is likely that inservice teachers and preservice teachers approach these situations differently. While inservice teachers' beliefs have been frozen by continued practice based on their beliefs and experiences, preservice teachers enter teacher education expecting to be taught how to teach, making them more susceptible to change. The teacher education program has the opportunity to expose receptive preservice teachers to experiences that unfreeze their pre-existing beliefs about teaching, and to provide them with continued experiences to reformulate their beliefs. The extent to which these new beliefs become frozen later in the classroom depends largely on the socialization process of beginning teachers, a time when beginning teachers are seeking to fit into their new surroundings.

The Role Of The Teacher In Classroom Discussion

As evidenced in the literature related to change in teachers' beliefs, methods courses are one source of experience that can influence change in teachers' beliefs about different aspects of teaching (Ball, 1988c; Ball, 1989; Cronin-Jones & Shaw; 1992). The NCTM Teaching Standards (1991) identify classroom discourse as a pivotal point in classroom practice where change
will need to occur. What, then, is the nature of classroom discourse that is called for?

A constructivist view of learning is the perspective on which the *Teaching Standards* and *Curriculum and Evaluation Standards* are based. A constructivist approach to mathematics instruction challenges a direct instruction model of teaching mathematics implying a shift in the teacher's role from telling and describing to listening and questioning in a probing mode of interaction (Confrey, 1990; Maher and Alston, 1990). Clements and Battista (1990) describe a learning environment in which children actively create knowledge about mathematics by working through cognitive confusion by reflecting on their physical and mental actions. This is done in collaboration with other learners in which mathematical ideas are established cooperatively through explanation, justification, and negotiation of meaning. Learning is a social process in which students are actively involved, interacting with one another as well as the teacher.

This social process can be typified by the nature of the discussion that takes place in the mathematics classroom. The *Teaching Standards* put a major emphasis on classroom discourse, and Standard #2 of the teaching portion of the document identifies aspects of the teachers' role in discourse.

The teacher of mathematics should orchestrate discourse by:
- posing questions and tasks that elicit, engage, and challenge each student's thinking;
- listening carefully to students' ideas;
- asking students to clarify and justify their ideas orally and in writing;
- deciding what to pursue in depth from among the ideas that students bring up during a discussion;
- deciding when and how to attach mathematical notation and language to students ideas;
deciding when to provide information, when to clarify an issue, when to model, when to lead, and when to let a student struggle with a difficulty;

- monitoring students' participation in discussions and deciding when and how to encourage each student to participate.

(NCTM, 1991, p.35)

This picture reveals that the teacher will continue to have an active part in the mathematics classroom, but in a different way. Instead of doing all the talking, explaining, and modeling, teachers will need to listen more and make decisions on what points to pursue as the students do the talking, explaining, modeling, and reasoning.

The term "discussion" conjures up many different images which include the teacher lecturing, the teacher leading the class in some form of recitation, and the students interacting as they develop understanding about a topic or concept. Some research takes a restricted definition of discussion to include only those classroom experiences in which students, or the teacher and the students, converse to share opinions or solve a problem (Hill, 1977; Dillon, 1984; Wilen, 1989). Other research focuses on the role of questioning (Gall, 1984; Dillon, 1984; Wilen; 1987) and non-questioning behaviors (Dillon; 1989) to determine the effectiveness of classroom talk.

Costa (1989) classified teacher behaviors to promote discussion in this sense into five categories: (a) structuring the classroom for discussion; (b) questioning to challenge students' intellect and imagination; (c) responding to create a climate for discussion; (d) metacognition awareness of the teachers' own behaviors; and (e) modeling behaving consistently with goals and objectives. Several of the behaviors parallel the intentions of the Standards. For instance, it was recommended that teachers promote discussion by engaging the students' intellect; inviting them to think; questioning; using
open or extending responses such as wait time, acceptance of students' ideas, asking for clarification, and making information available to students; and reflecting on their discussion strategies.

Dillon (1989) summarized research on alternatives to questioning during class discussions. These techniques illustrated the effectiveness of reducing the teacher talk in ways that promote student contributions. The alternatives presented included having students pose questions, sending signals to indicate the teacher is receiving what the student is saying, observing deliberate periods of silence before and after a student speaks. Dillon concluded that alternatives to questioning "enhanced the students' cognitive, affective, and expressive processes, leading to better discussions" (p.94).

The effectiveness of different questioning techniques have been the subject of teacher effectiveness practice and research (Blosser, 1973; Gall and Rhody, 1987; Wilen; 1987; Rowe; 1974). Research has indicated that not all questioning is effective. It is important to ask the right question at the right moment. Questions have been classified according to the response they are intended to evoke. A general classification for which much research has been reported is higher- or lower-cognitive questions (Gall and Rhody, 1987). More specific classifications have up to as many as 15 question types listed under four categories: cognitive memory, convergent thinking, divergent thinking, and evaluative thinking (Blosser, 1973). Effective teaching techniques that help students respond well to questions include keeping all students on task, phrasing questions clearly, providing wait time, responding constructively to students' answers, and probing student answers to improve them (Gall and Rhody, 1987).
Aspects of discussion specific to mathematics instruction have been the object of research. Lo, Wheatley, & Smith (1991) attempted to understand mathematics classroom learning by focusing on classroom discussion. The term "mathematics class discussion" referred to:

a class activity with the following characteristic: 1) student interpretations of a mathematical task is the focus of the activity, 2) student-to-student interaction is encouraged, and 3) the teacher's role is to facilitate student-to-student communication rather than to guide or evaluate. (p.1)

Applying a constructivist view, they examined the participating third-grade teacher's role in discussion as a facilitator while students discussed their methods of solution to assigned problems. Results indicated that the ability to "discuss" mathematics took time to develop, as the social roles of the students and the classroom teacher took time to be established.

The Standards emphasize communicating in mathematics (NCTM, 1989 & 1992; Rowan, Mumme, and Shepherd, 1990; Capps, 1992). Recent developments in the use of technology, problem solving, and cooperative learning in mathematics education have had an impact on the type of discussions that take place in the mathematics classroom. Problem solving becomes the medium for student inquiry. This takes the focus off the teacher and encourages students to develop and communicate their own ideas. Small groups provide a forum in which those investigations take place, improving cooperation and problem-solving skills (Suydam, 1987). Technology in the form of microcomputers and calculators affects the type of interactions in the classroom by placing a increased emphasis on student collaborative learning (Hawkins and Sheingold, 1986; Farrell, 1989). Mathematics classes in which students solve problems in small groups using technology help create the atmosphere imagined by the Standards. The use,
however, of a problem-solving inquiry-oriented approach does not guarantee that learners will respond as envisioned (Tharp, 1992).

**Theoretical Framework**

The picture painted by the *Teaching Standards* does not necessarily conform to the actual practice that takes place in mathematics classrooms today. It is important for the purpose of this study to describe a framework of current practice to compare the practice of the *Teaching Standards* and into which we can place the beliefs of the preservice secondary mathematics teachers. As reported by Thompson (1992), Kuhs and Ball proposed a model that identified four dominant and distinctive views of how mathematics should be taught. The four views of teaching are:

1. **Learner-focused**: mathematics teaching that focuses on the learner's personal construction of mathematical knowledge;
2. **Content-focused with an emphasis on conceptual understanding**: mathematics teaching that is driven by the content itself but emphasizes conceptual understanding;
3. **Content-focused with an emphasis on performance**: mathematics teaching that emphasizes student performance and mastery of mathematical rules and procedures; and
4. **Classroom-focused**: mathematics teaching based on knowledge about effective classrooms. (p.136)

In the description of these models, aspects of the teacher's role in conducting classroom discussion are presented. From the "learner-focused" perspective, the teacher is a facilitator, asking questions that engage the students in mathematical thinking and enabling them to construct their own knowledge. The teacher's role from the "content-focused with emphasis on understanding" perspective would be similar to that from the "learner-focused" perspective with the belief that understanding is constructed by the learner, but that content is not organized by the interests and ideas of the students, but by the structure of mathematics. In the "content-focused" view...
with an emphasis on performance perspective, the role of the teacher is essentially to show the students how to perform skills. This means that the teacher will demonstrate skills, explain how to do them, and define the material to which they will be applied, usually presenting it in an expository style. From the "classroom-focused" perspective, efficient methods determined through research is the determining factor for classroom practice. Many classroom practices have been identified by process/product research. Cruickshank (1990) compiled effective teaching practices identified through research that include such behavior variables as: clarity, organization, enthusiasm, task-oriented, achievement oriented, and/or businesslike behavior, and variability. Teachers with this perspective would incorporate such behaviors in their teaching.

Preservice secondary mathematics teachers' beliefs will not cleanly fit into any one particular perspective on teaching in general nor on teaching mathematics in particular. Practice supported by the Standards would most closely correspond to the "content-focused with emphasis on understanding" or the "learner-focused" perspectives, while current practice would correspond most closely to the "content-focused view with an emphasis on performance" perspective. However, this framework provides elements by which the discovered beliefs of the participants can be categorized and to which the Teaching Standards can be compared.

Summary

Bringing these component variables together, the following picture emerges. Preservice secondary mathematics teachers bring beliefs about mathematics and mathematics teaching with them into the teacher education program based on their prior experiences as learners in the mathematics
classroom. These beliefs influence their behavior in the classroom, particularly in the way they will carry out their perceived roles in conducting discussion in the mathematics classroom. Based on the NCTM Standards and Teaching Standards, the nature of that role is presently being reexamined and reformulated by the mathematics education community to reflect methods that are not predominant in mathematics classes today. The mathematics and general methods courses and field experiences constitute the setting in which preservice secondary mathematics teachers' beliefs will be challenged or affirmed. This study investigated the extent and depth preservice secondary mathematics teachers' beliefs with respect to the teacher's roles in discussion in the mathematics classroom and changes that occurred as a result of participation in the methods courses and field experiences.
CHAPTER III
METHODOLOGY

To respond to the research questions formulated, an in-depth examination of the participants' beliefs is required. Therefore, naturalistic inquiry in the form of interviews was chosen to provide qualitative data from participants in the study. Interviews are an interactive method that enable the researcher to exercise a certain amount of control in order to procure the information necessary from the participants. This benefit is counteracted, however, by the possibility that the method can produce an observer effect that may lead participants to deliberately or unconsciously supply false or misleading data (Goetz & LeCompte, 1984). For this reason, the researcher decided to triangulate the interview data with journal entries of the participants' field experiences; interviews with the methods course instructors, university supervisors, and cooperating teachers; classroom observations of methods course instruction; and observations of the preservice teachers teaching practice during the field experience. Content analyses were performed to identify patterns of experience and beliefs participants bring to the teacher education program with respect to their role as teachers in mathematics classroom discussions, of experience they engage in during the methods courses and field experiences, and of changes in beliefs toward the belief object as reported and observed in participants. The following sections describe the methods employed in the participant selection
for the case studies, instruments development, data collection, and data analysis for the study.

**Population Studied.**

Since the study proposes to investigate incoming preservice secondary mathematics teachers' beliefs and the changes that occur while preservice teachers participate in methods courses and field experiences, subjects needed to be chosen before they have participated in teacher education courses or have been exposed to the *Teaching Standards*. Therefore, juniors entering the secondary mathematics education program of a large mid-western land-grant university in the fall of 1992 constituted the population under investigation.

The program in which the preservice teachers were enrolled was a two-year long program with a structured sequence of courses in mathematics and general education methods courses, field experiences, and a minimum requirement of 60 quarter hours in mathematics beyond the calculus level. Methods course instruction during the junior year of the program includes: (1) Ed. T&P 546, a 6-credit course to teach methods in secondary school mathematics, taken during the autumn quarter; (2) Ed. T&P 450, a 6-credit course to teach learning theories in education, taken during the winter quarter; and (3) Ed. T&P 451, a 6-credit course to teach general teaching methods, taken in the spring quarter. Field experiences during the junior year of the program include: (1) placement at the elementary, middle school, and high school levels during the first three quarters respectively for two mornings per week; and (2) 3-day placements in elementary and secondary schools, and in special education facilities. Preservice teachers mathematics
requirements are left up to the preservice teachers to complete at any time prior to graduation.

In order to choose the subjects to be studied in depth, the following screening process was employed. A questionnaire was administered to the entire junior class the first week they entered the methods course. The class consisted of 14 preservice teachers, 9 females and 5 males. All 14 preservice teachers responded to the questionnaire. Of the 14 respondents, 9 preservice teachers, 2 males and 7 females, were willing to participate in the study and entered into the second phase of the selection process. Each of the nine preservice teachers was interviewed using the first interview protocol. This interview sought clarification on the questionnaire responses and further information concerning the preservice teachers' experiences in their secondary school mathematics classes.

After this data was collected, four preservice teachers were selected to participate in the case studies using the following criteria. Employing the Teaching Standards as a point of reference, seven characteristics of mathematics classroom discussion advocated by the Teaching Standards were identified. The antitheses of these seven characteristics form a continuum for each of the characteristics on which the experiences and beliefs of the preservice teachers can be placed. The seven characteristics and their antitheses are identified in the table below.
Table 1. Mathematics Classroom Discussion Characteristics.

<table>
<thead>
<tr>
<th>STANDARDS</th>
<th>NON STANDARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Flow of ideas comes from students.</td>
<td>1. Flow of ideas comes from the teacher.</td>
</tr>
<tr>
<td>2. Frequent student/student interaction in small group or large group settings.</td>
<td>2. Infrequent student/student interaction.</td>
</tr>
<tr>
<td>3. Students are frequently asked to clarify and justify their ideas.</td>
<td>3. Students are mainly asked to perform tasks without justification.</td>
</tr>
<tr>
<td>4. Acceptance of ideas is determined by the class community.</td>
<td>4. Acceptance of ideas is determined by the teacher.</td>
</tr>
<tr>
<td>5. Tasks are chosen to initiate discussion.</td>
<td>5. Tasks are chosen to comply with textbooks and curriculum.</td>
</tr>
<tr>
<td>6. Students are allowed to struggle to answer questions.</td>
<td>6. Teacher acts to alleviate student struggles.</td>
</tr>
<tr>
<td>7. Teacher orchestrates discussion by listening to students' input and makes decisions based on that information.</td>
<td>7. Teacher explains, tells, demonstrates what students need to know.</td>
</tr>
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</table>

Preservice teachers responses on the questionnaire and during the first interview were categorized according to these characteristics as either Standards-like or Non-Standards-like. Responses and statements were also classified as being part of the preservice teachers' prior experiences or part of
their belief structure. These two classifications enabled the researcher to formulate a 2 x 2 grid into which statements could be classified. The four cells of the grid included: (1) Standards-like Beliefs; (2) Standards-like Experiences; (3) Non-Standards-like Beliefs; and (4) Non-Standards-like Experiences. See appendix B for an example of the grid.

A grid was then filled out for each of the 9 preservice teachers interviewed in the selection process. A tally of responses was made in the grid for each preservice teacher. Totals for each cell were established and an index of experiences and beliefs was determined by taking the difference between the totals in the two beliefs cells and the two experiences cells. This difference produced a number that favored either the Standards-like category or the Non-Standards-like category. By choosing a positive orientation to Standards-like responses and a negative orientation to the Non-Standards-like responses, those differences were either positive or negative and were then graphed on a coordinate axis, with the horizontal axis corresponding to experiences and the vertical axis corresponding to beliefs. Appendix C presents the placement of each individual in that coordinate system.

The preservice teachers for the case studies were then chosen based on two conditions whose satisfaction created a desired amount of variability in participants: (a) greatest distance from the origin in each of the quadrants in the coordinate system, and (b) sex. As seen by the grid, none of the preservice teachers reported having experiences that reflected the Standards, but the reported beliefs ranged from slightly Non-Standards-like to strongly Standards-like. The four preservice teachers that were asked and accepted to participate represented the two preservice teachers with the highest index for Standards-like beliefs, and the two preservice teachers with the highest index
for Non-Standards-like beliefs. These same four preservice teachers also satisfied the gender condition established, since two were males and two were females.

**Data Collection.**

The researcher used a non-participation philosophy towards the collection of data. This decision was made in an attempt to minimize the reaction between the informant and the researcher in the belief that frequent and intense interaction would stimulate the informant to change their beliefs toward their role in discussions in mathematics, either because of their heightened awareness to potential needs to change or to please the researcher (Goetz and LeCompte, 1984). With this approach in mind, standardized open-ended interviews were utilized to collect data and the researcher audiotape recorded all the observations from a low-profile position in the classroom that enabled the best recording of the observation, while intruding in the classroom experience as little as possible.

Prior experiences and beliefs concerning the teacher's role in discussions were established during the screening process for the study. The remaining research questions posed by the study involved determining how those beliefs were challenged and changed by the preservice teachers' participation in the teacher education program during the first two quarters of their junior year. In order to assess that change, two sources of direct data from the preservice teachers were examined. First, the preservice teachers' journals, kept throughout the quarter, were collected and read throughout the quarter to assess the effects of the field experiences on the preservice teachers' beliefs. Secondly, the preservice teachers were interviewed at the end of the quarter to examine changes that might have occurred in their
beliefs about how they would be conducting discussions in the mathematics classroom.

This direct data from the preservice teachers was triangulated with indirect sources of data. These sources were chosen for their direct contact with the preservice teachers and their possible influences on the object of the study, the preservice teachers' beliefs about conducting discussions in the mathematics classroom. The secondary sources included interviews with the methods course instructors, the university supervisor for the field experiences, and the cooperating teacher for the field experiences. Observations of the methods classes and the preservice teachers' teaching were analyzed for validation of informants' data and the connection between expressed beliefs and behavior.

Visits were made to the field experience location twice during the first quarter, and three times during the second quarter for each preservice teacher. Audiotapes were made of the observations and reviewed by the researcher for confirmation of the preservice teachers' expressed beliefs. Observations of the methods class participation were also audiotaped and reviewed for class content in the methods classes and participation by the preservice teachers that indicated expressed views related to the research topic.

**Instrument Development.**

"The validity and reliability of qualitative data depend to a great extent on the methodological skill, sensitivity, and integrity of the researcher" (Patton, 1990, p.11). Keeping this thought in mind, the content and face validity of the questionnaire were established in the following ways. The questionnaire was distributed to a panel of four judges to establish content validity. Judges were asked to comment on whether or not the questions
assessed the subjects' prior experiences and beliefs about classroom discourse. Their reactions were used to modify the questions. Following this process, the questionnaire was field tested on a population of preservice teachers beginning their post-degree studies as mathematics education majors. The questionnaire was administered to this group, followed by a discussion as to the validity and representability of the questionnaires' representation of mathematics classroom experience. Participants' responses and reactions to both instruments were registered and utilized to modify the instruments, if necessary. The results of these two procedures established the content and face validity of the instruments. A panel of judges was used to validate the standardized open-ended interviews utilized for the preservice teacher, methods class instructor, university supervisor, and the cooperating teacher interviews.

Six instruments were required to gather appropriate data. They were as follows:

**Instrument # 1: Initial Questionnaire.**

This instrument was composed of two scenarios of mathematics teaching practice and questions with respect to the scenarios seeking responses for two objectives. The first objective was to establish the nature of prior experiences of the preservice teachers in the mathematics classrooms. The second objective was to establish baseline information regarding the preservice teachers' beliefs about the role of the teacher in those discussions. Three types of questions were used to accomplish those objectives. One type of question was closed-ended, asking preservice teachers to qualify their responses by choosing one out of a list of possible choices. Another type was open-ended, allowing preservice teachers to furnish their own answer to the
question. The third type asks preservice teachers to qualify their responses by indicating the position of their response on a spectrum from 1 to 10. Demographic data was collected at this time.

**Instrument # 2: Initial Preservice Teacher Interview.**

The objective of this open-ended interview was to probe into the responses registered by the preservice teachers on the initial questionnaire in order to establish the preservice teachers' prior experiences and incoming beliefs as they entered the teacher education program with respect to the role of the teacher in mathematics class discussion. Questions were tailored to solicit elaboration on prior responses, verifying previous information and enabling the researcher to place further trust in the responses.

**Instrument #3: Second Preservice Teacher Interview.**

The objective of this interview was to present the preservice teacher with the picture that emerged from the first interview of the preservice teachers' beliefs about the role of the teacher in mathematics class discussion. An interview guide (Patton, 1990, p.283) determined how participation in the methods course and field experiences have either reinforced the beliefs identified in the initial interview or created learning situations in which those beliefs had been challenged. In the case in which beliefs had been challenged, the guide probed the informant to identify the extent and direction of movement away from initial beliefs.

**Instrument #4: Final Preservice Teacher Interview.**

The objective of this interview was to present the preservice teacher with the picture that emerged from the second interview concerning the preservice teachers' beliefs about the role of the teacher in mathematics class discussion and to determine how participation in the second quarter methods
course and field experiences had either reinforced or challenged those beliefs. The guide was divided into ten sections: (a) a member check on prior experiences and beliefs; (b) preservice teacher knowledge regarding discussion formats; (c) the impact on the preservice teacher's beliefs of participation in Ed. T&P 450; (d) the impact on the preservice teacher's beliefs of participation in the field experiences; (e) a self-assessment of the preservice teacher's teaching based on audiotape segments of classes the preservice teacher taught; (f) the impact on the preservice teacher's beliefs of participation in the bi-weekly seminars with the mathematics methods instructor; (g) the impact on the preservice teacher's beliefs of interactions with the university supervisor; (h) the impact on the preservice teacher's beliefs of contacts with classmates outside of formal settings; (i) a hypothetical situation in which the preservice teachers describe a model lesson for teaching fractions, and (j) the preservice teacher's evaluation of what will be needed in teacher education to enable him/her to become an effective teacher during classroom discussions. The guide probed the informant to identify the extent and direction of movement away from initial beliefs that might have occurred as a result of their participation in the teacher education program during the second quarter.

Instrument #5: Methods Course Instructor Interview.

The objective of this instrument was to determine how the methods instructor planned to treat the topic of the role of classroom discussion in the course. The interview guide was designed to: (a) determine the exposure the preservice teachers had during participation in the methods classes to the Teaching Standards or to methods having similar foundations; (b) enumerate course objectives with respect to the role of the teacher in mathematics class discussion; (c) determine discussion methods modeled in the methods
(d) determine methods to assess preservice teachers understanding of the role of the teacher in mathematics class discussion.

**Instrument #6: Cooperating Teacher Interview.**

The objective of this instrument was to determine the nature of the experience the preservice teachers had during the field experience. Three avenues of inquiry were examined: (a) the self-described teaching behaviors of the cooperating teacher that the preservice teacher would have observed; (b) observation by the cooperating teacher of critical events that the preservice teacher was involved in during the field experience; and (c) observations by the cooperating teacher of changes that the preservice teacher exhibited as a result of participating in the field experience. Demographic data provided by the cooperating teacher included years in teaching, prior experience with preservice teachers, membership in the NCTM, and interactions with the university supervisors.

**Instrument #7: Ed. T&P 450 Course Instructor Interview.**

The objective of this instrument was to determine how participation in Ed. T&P 450 might have impacted the preservice teacher’s beliefs about their role in discussion in the mathematics classroom in particular and their view of their role in discussion in the classroom in general. The questions focused on three possible contributors to that impact: (a) the course content; (b) field experiences at the elementary and secondary levels; (c) laboratory teaching experiences; and (d) discussion techniques modeled by the instructor.

**Data Analysis.**

The principal objective of analysis of the data generated in this study was to identify patterns, themes, and categories of the beliefs of each of the participants with respect to their role as teacher in mathematics classroom
discussion. Data was reviewed at three levels. At the first level, data was reviewed as it was collected. Journal entries were read and highlighted for ideas that were related to the object of the study. Field notes were taken to supplement the audiotaped accounts of the methods class and preservice teacher observations.

At the second level, data was reviewed to formulate member checks of the preservice teachers at the end of the first and second quarters. Data from the screening interview and questionnaire provided the basis for the member check at the end of the first quarter. Data collected from the first quarter and the end of the quarter interview provided the basis for the member check at the end of the second quarter.

The third level of analysis began after all the data from the study was ready for a thorough analysis. The categories established for the selection of the participants were utilized as a framework in which patterns in preservice teachers' beliefs and behaviors were identified. Transcripts of each interview and modified transcripts of each observation were made. Copies of the transcripts were made on colored paper to identify the source and nature of the data. Direct data came from the students' journals and interviews. Indirect data came from the cooperating teachers, the university supervisors, the methods class instructors, and the inferences of the researcher. Maintaining the use of the categories provided baseline data from which comparisons could be made to chronicle the development or lack of development in the preservice teachers' beliefs and behaviors concerning their role in discussion in the classroom.

The profile of each case was formulated by comparing the incoming beliefs and intended behaviors with the beliefs and observed behaviors
registered throughout the fall and winter quarters. The profile was updated for each time interval and a summary of the evolution of the final profile is provided. The developments of these profiles were compared across the four cases, and conclusions were made concerning each preservice teacher and the overall process.

**Definition of Terms.**

Before reporting the results of the study, terms were utilized throughout the report that need to be defined.

1. **Beliefs.** Certain types of judgements about a set of concepts.
2. **Discussion.** The thoughtful and organized conversations that take place in the classroom to teach a mathematical concept.
3. **Cooperating Teacher.** The teacher assigned to oversee the preservice teacher during the field experience related to the mathematics methods course.
4. **Lecture.** The method of instruction in which the teacher verbally presents course content to students.
5. **Preservice Teacher.** Students enrolled in the secondary mathematics education program taking the role of the teacher during field experiences.
6. **Recitation.** Recurring sequences of teacher question plus student answer, where students demonstrate what they already know or are coming to know through questioning.
7. **Student-Centered Instruction.** A student-centered/inquiry approach to teaching mathematics is based on a view of mathematics as a problem-solving process in which teachers provide tasks that enable learners to
build and refine their understanding of mathematical concepts in a community of learners.

8. **Teacher-Centered Instruction.** A teacher-centered/transmission approach to teaching mathematics is based on a view of mathematics as a collection of facts, rules, skills, and processes in which the teacher demonstrates the desired skills with adequate explanations and students listen, assimilate ideas, and solve problems as modeled by the teacher.

9. **University Supervisor.** The graduate assistant assigned to visit the preservice teacher during the field experiences related to the mathematics methods course.

**Limitations and Delimitations of the Study.**

The study had several aspects that need to be noted prior to discussing its results and conclusions. First, the researcher recognized that the decision to maintain a non-participatory role during data collection had its advantages and disadvantages. By maintaining that position, the researcher was not seen as part of the process, allowing the informants to be open about the perceived strengths and weaknesses of the program during interviews. This was perceived as an advantage by the researcher. However, the decision not to interview the preservice teachers on a more frequent basis in order not to influence the preservice teachers to engage in self evaluation when they would not normally have done so, can be seen as being a disadvantage.

The researcher recognized that a greater amount of inference was made on the researcher's part in order to fill in the gaps left by less frequent direct contact with the informants. The researcher's position on this point was that if self evaluation was to take place, it should have been done at the urging of the players involved in those activities, either the university supervisors or
the cooperating teachers, with the researcher questioning about those experiences in the scheduled interviews. The methodology compensated for this by triangulating informant data with data received by interviewing the methods course teachers, the cooperating teacher, and the university supervisors.

The second aspect addressed the scope of the study. Beliefs are not formulated in isolation, and teaching practices, such as how teachers perceive their role in conducting discussions in the mathematics classroom are part of a beliefs system. Beliefs about the teacher's role in discussion are influenced and tied to teachers' beliefs about the nature of mathematics, mathematics teaching, and teaching in general. The researcher recognized that this study did not investigate the web of beliefs, but only one strand; the beliefs about discussions in the mathematics classroom.

Third, because of the qualitative design of the study and the small number of informants, generalizability to other groups of individuals was not advisable. However, the objective of the case studies was to describe what was and to seek to generate theory that could be further studied for wider generalization. It was not the intention of this study to extend conclusions beyond the phenomenon experienced by the group under study, but rather that the data analyzed contributed to a foundation for further understanding of how preservice teachers' beliefs about a particular aspect of teaching change during participation in the teacher education program and the specific influence that methods courses and field experiences have in the initial stages of that participation.

Finally, as an instrument of the study, the researcher's ability to remain neutral and nonjudgemental throughout the investigation was a crucial
factor on the validity of the study. Maintenance of an openness by the researcher to feedback from collaborators and counselors was intended to insure the integrity of the study. However, the researcher acknowledged having a bias towards the *Teaching Standards*. Every effort was made not to introduce that bias into the interactions with the participants throughout the interview process. With these limitations and delimitations in mind, the results are presented.
CHAPTER IV

DESCRIPTIONS OF FIRST AND SECOND QUARTER LEARNING EXPERIENCES FOR THE PARTICIPANTS

As part of a cohort of 14 preservice teachers, the participants in the study had certain common experiences with respect to their participation in the Mathematics Methods Course during the first quarter, their participation in the Professional Introduction to Education Course and the seminars to discuss the NCTM Standards during the second quarter, and the field experiences they had related to mathematics education during the first and second quarters. This chapter will describe those common experiences and delineate the vocabulary that will be used in the description of the cases.

Fall Quarter

Mathematics Methods Course.

The Mathematics Methods Course was taught by Dr. Anne Jols. The class met three times per week, Monday, Tuesday, and Wednesday, for three hours. The goal of the course was to examine the curriculum, instruction, and forces that influence teaching and learning in K-12 mathematics classes. A major emphasis was given to the current reforms in mathematics education as proposed by the NCTM in the Standards. The course syllabus was organized around the curriculum topics in the Standards, and its four unifying themes: mathematics as problem solving, mathematics as connections, mathematics as communication, and mathematics as reasoning.
The curriculum topics included: estimation; number sense; whole number operations and computations; geometry and spatial sense; measurement; statistics and probability; fractions and decimals; patterns, relationships, and functions; algebra; trigonometry; discrete mathematics; and calculus. Instructional methods for the elementary level were presented, and modifications of these methods for use in the middle and high schools were discussed.

Preservice teachers had to satisfy four requirements. First, they were required to do extensive reading for the topics to be covered that week. Each preservice teacher had to turn in at least two reactions papers to readings each Monday. Extra readings received extra credit. One of the readings was required to be from either the *Standards*, or the department called "Implementing the Standards" in the *Mathematics Teacher* or the *Arithmetic Teacher*. The second reading was required to come from the *Mathematics Teacher* or the *Arithmetic Teacher* or another mathematics education journal on an activity to be used in the elementary or secondary school classroom. The second requirement was additional readings selected by the class on topics generated by class discussions. Third, each preservice teacher was required to develop a game for use in an elementary, middle, or high school mathematics class. Fourth, each preservice teachers was required to make a file of ideas related to a high school course of their choice. These requirements constituted 55% of the course grade. The remaining 45% consisted of midterm and final examinations, and class participation.

Dr. Jols' instructional goals were based on her knowledge of educational research in general and of mathematics education research, in particular. She frequently would make reference to what research said about any particular
topic covered in the course. Several instructional goals were related to the teacher's role in discussion. First, the kind of discussion Dr. Jols wanted to develop in the preservice teachers focused on questioning. She stressed that questioning was a technique to involve students in the classroom discussion. Preservice teachers were encouraged to have students justify their answers by asking the "why" question, thus reinforcing mathematics as reasoning, an idea emphasized by the Standards. When talking about how she taught the preservice teachers the importance of asking the "why" question, the methods instructor reported:

So that when you talk about questioning even, I would think that you are aware that I am coming back many times to make sure what's the major question. We talked about lesson plans the other day, and what do we need to ask in the procedures, And it took them 2 or 3 tries before they finally hit questions. Then when I said what's the most important question, they got "why" right away.

Dr. Jols made preservice teachers aware of the importance of wait time allotted after a question was asked and listening to students in order to guide the questioning.

Second, Dr. Jols's modeled different practices that promote good discussions in the classroom. When she designated a preservice teacher to monitor discussions in which preservice teachers critiqued articles they had read, she remained neutral, only intervening if necessary. She wore sunglasses on several occasions so that the preservice teachers could not make eye contact with her, forcing the students to direct their answers to each other. After discussions, she attempted to make the preservice teachers aware of any particular behavior she was modeling or was modeled by the preservice teachers when they were conducting the discussions. She commented at the end of the quarter:
Again, this morning, when a couple of them did it (questioning) particularly well, I pointed out to the group, 'Did you notice, they did involve you, even though they were seemingly in an explanatory mode.'

In one class during the quarter, the daily topic was discourse. The class discussed how the methods class instruction modeled many of the points made in the *Standards* about the teacher's and student's role in discourse.

Third, Dr. Jols stressed the use of tools such as manipulatives, calculators, and problem solving in the mathematics classroom. Although Dr. Jols wanted to make the role of these tools in discussion a part of the preservice teachers' experiences, no direct instruction was given to indicate to preservice teachers how those tools would affect discussion. When asked at the end of the quarter to describe how the connection was made between discussions and those tools, she responded:

I didn't answer it directly. I knew that through the discussion we're having as the result of the work with the overhead in particular, that that's where it comes out.... At other points in time as we're talking about why do you bother teaching this topic, how does the calculator change what you're doing here. What I'm really saying is it's very difficult to say it happens here and there. It happens in small bits at a time. I would hope that they recognize it that way, but I wouldn't want to bet on it.

Dr. Jols felt that this was particularly true about the preservice teachers use of problems to introduce lessons. The problems she would use in instruction were mainly teaching problems, and she was not sure that preservice teachers would open their own classes with problem solving.

Dr. Jols varied the format of the methods class over the course of the quarter. Her general approach was to hold discussions with some form of preservice teachers preparation. This included group presentations of prepared activities using manipulatives, calculators, and problem solving;
discussions of articles read by the preservice teachers and reviewed by a peer; and prepared materials by the professor.

In summary, instruction on discussion in the mathematics classroom was woven into the experiences of the preservice teachers over the course of the quarter using the technique of bringing ideas to the attention of preservice teachers based on how discussion would be affected during the instruction of a particular mathematics concept. Dr. Jols referred to this as the teachable moment. When particular techniques were modeled, they were brought to the attention of the preservice teachers by the methods instructor. Little direct instruction was given on particular discussion techniques, except for one class that focused on discourse as described in the Standards. Although those techniques were modeled in the methods class instruction, Dr. Jols was not convinced that preservice teachers were able to transfer them into their own mathematics instruction.

Field Experiences.

Each student was required to enroll in ED T&P 489.02 and, the field experience for the fall quarter. This course, the first of a series of three field experiences, placed the preservice teachers in elementary school classes in a suburban school district. Preservice teachers spent three hours every Thursday and Friday under the surveillance of a cooperating teacher. The course was designed to help preservice teachers improve their knowledge and skills of teaching mathematics.

Four requirements were made of the preservice teachers. First, each preservice teachers had to maintain a journal of their experiences, focusing on what they observed, as well as their impressions and reactions. Questions to be considered while writing the journals involved teachers' behaviors,
strategies used in leading discussions, teacher/student and student/student interactions, teacher preparation for small group instruction, use of manipulative materials, teacher consideration of different student learning styles, the different approaches taken by the teacher for different subjects, and children's reactions, individually and as a class, to instruction.

Second, preservice teacher's teaching skills were evaluated by the cooperating teachers, the university supervisors, and the methods course instructor. Assessment of those skills focused on the preservice teacher's involvement, their use of teaching methods such as those discussed in the methods course, and how much improvement they showed over the course of the quarter.

Third, each preservice teacher was required to design a bulletin board. Suggestions for the subject of the bulletin board could come from the cooperating teacher or from the preservice teachers. Each bulletin board had to be interactive in which the children were required to do something more than just look at it.

Fourth, attendance was important. Each student was required to know the phone number of the cooperating teacher in order to communicate any necessary absence in advance. Although not given a percentage of the grade, poor attendance resulted in lower grades.

Each cooperating teacher received a copy of the requirements from the university. However, no clear cut instructions were given to the cooperating teachers with respect to specific objectives that they were to work on with the preservice teachers. Each cooperating teacher was left on their own as to what skills on which they were to work. Each cooperating teacher was asked to
evaluate the preservice teachers' performances, but the course grade was essentially assigned by the university supervisors.

**Winter Quarter**

**ED T&P 450: Professional Introduction to Education.**

Each preservice teacher was required to enroll in this course during the winter quarter. These classes were made up of preservice teachers from various disciplines. The mathematics education preservice teachers made up approximately 15% of the total of the three classes observed. The goal of the course was "to increase preservice teacher awareness and understanding of school-aged learning development and its relation to individual diversity and teacher effectiveness." Since the preservice teachers could sign up for one of three sections offered during that quarter, not all of the participants of the study were in the same class. However, since a common syllabus and departmental examinations were employed by the teaching assistants that taught the course, a consistency in the course content and mode of instruction was achieved. Students attended classes for two and one half hours per day, Monday, Tuesday, and Wednesday of each week.

The requirements of the course covered a wide range of activities. Preservice teachers were evaluated on: (a) participation, scholarly effort, and attendance; (b) two midterms and a final examination; (c) presentation of two reflective teaching lessons and participation as students in other reflective teaching lessons; (d) a critique of a current journal article; (e) a written and orally presented position paper; and (f) a Field Observation Report of visits to an elementary school, a high school, and COSERRC, a school for special needs students.
Instruction of the course content was organized around readings from the textbook, *Educational Psychology*, by Eggen and Kauchak (1992). Topics covered included the developmental theories of Piaget, Kohlberg, and Erickson; individual learning styles; teaching exceptional students; theories of motivation; behavioral views of learning; and cognitive views of learning. The common focus of these topics was the learner.

Implications for teaching were then brought out through the predominant instructional method utilized by the teaching assistants: discussion. In each of the classes observed, some form of cooperative group work was followed by an open discussion of group findings with the teaching assistant acting as the facilitator. The term facilitator was used by one of the teaching assistants to describe her role in classroom discussions. The goal of the teaching assistants was not to be the disseminator of information, but the developer of critical thinking on the part of the preservice teachers. In this respect, the teaching assistants modeled discussion formats for the preservice teachers, but these discussion formats were not the object of direct instruction.

Six observations of the three classes (two each per instructor) were made. The topics examined during the observations were a debriefing of the field experience at the elementary school, theories of motivation, multiculturalism, at risk students, personality types, simulations classroom experiences, a debriefing of the field experience at the secondary school, reinforcement, and a reflective teaching exercise. The instructors each utilized a combination of full class discussion with small cooperative learning group work. A typical class consisted of some preparation on the part of all students with respect to a topic. A task was given to the students that normally required some small group collaboration. Synthesis of the
experience was mediated by the instructors. A typical example of this involved the class on multiculturalism conducted by Carrie. Students were asked to break up into groups according to subject matter, and given the task of identifying ways that the teacher could bring multiculturalism into the classroom. The students worked for a given amount of time, usually 10-20 minutes, and then were required to report back to the group. During the reporting time, the instructor would use the ideas mentioned in order to cover the material required by the syllabus.

Each instructor made an effort to make students aware of the teaching techniques being used. Joan often announced what she had done and why she was doing it. An example of this was explaining to the class how she had decided to vary the small group structure in the class by asking them to form groups according to the personality type they had discovered through the use of the Keirsey Temperament Sorter.

Although the students did participate in reflective teaching and teaching simulations, the teacher's role in discussion in the classroom was not directly treated. The central goal of the instructors with respect to teaching and learning was to illustrate how each of the theories and topics studied would impact the teaching and learning experience in the classroom. One assignment Judy gave required students to define terms related to a given topic and asked each group to write a classroom application and/or implication for teaching and learning for each term. Direct instruction on discussion was not part of the course syllabus.
Field Experiences.

In the winter quarter field experience for the mathematics education program, preservice teachers were placed in middle schools in suburban schools close to campus. This experience was the second in the progression of placements of preservice teachers in elementary, middle, and secondary schools. Preservice teachers again visited their schools for three hours each Thursday and Friday.

The focus of the course was on (a) observation of the classrooms and of a particular student or students, (b) diagnosis of the needs of an individual or a small group of students, and (c) intervention with that individual or small group, including the preparation of lesson plans. If deemed appropriated by the cooperating teacher, preservice teachers planned and taught one or more lessons to the entire class. These conditions were flexible based on the cooperating teacher and the student. One participant, John, changed the schedule completely to accommodate his participation in athletics at the university.

In addition to the fall quarter requirements of keeping a journal, producing lesson plans, the development of teaching skills, and mandatory attendance, preservice teachers were asked to write reaction papers to the NCTM Teaching Standards. After one paper, Dr. Jols was asked to allow the students to discuss the readings in meetings every other week. Although the topic of discussion was to be the Teaching Standards, the meetings became more of a debriefing session in which students discussed topics relevant to what they were experiencing in their schools. Sometimes the discussions dealt specifically with the Standards, but more often than not the preservice teachers discussed what was important to them in their schools. These
meetings will be referred to as Dr. Jols' seminars throughout the descriptions of the cases, and provided considerable insight into what was important to the preservice teachers, and how they were functioning in their classrooms.

The cooperating teachers involved in the field experiences were usually part of a teacher development project administered by the university. Although this meant a deeper contact with the university, the cooperating teachers were also in the process of examining their teaching, and didn't always provide teaching models that reflected the recommendations in the Standards, a fact that came out frequently in the seminar meetings.

Case Studies.

The cases making up the next four chapters are presented in three parts. Each part presents a profile of the individual's experiences and beliefs concerning discussion in the mathematics class at three points in time during their first year preservice secondary mathematics teachers. At the beginning of the fall quarter, the incoming classroom experiences and beliefs the preservice teachers expressed as they entered the secondary mathematics education program were examined. At the end of the fall quarter, the impact of mathematics methods class and related field experiences on preservice teachers' expressed beliefs about their role in discussions in the mathematics classrooms were examined. At the end of the winter quarter, the impact of the preservice teachers' participation in the Professional Introduction to Education and mathematics education field experiences on their expressed beliefs about their role in discussions in the mathematics classrooms were examined.
CHAPTER V
THE CASE OF JOHN

Background.

John was a 20-year-old junior entering the secondary mathematics education program. He went to school in an urban area in upstate New York where he took mathematics classes each of his six years in secondary school, finishing with precalculus as a high school senior. He completed two years of computer science courses during his high school years. At the time of his first interview, he held an overall grade point average of 3.4 out of a possible 4.0 and a grade point average of 3.2 in his college mathematics courses.

Confidence was important to John. He recognized that he was reluctant to participate in activities in which he would not feel comfortable about his contribution to the activity. His confidence in his own mathematical ability was reflected in his willingness to take leadership positions in the classroom situations during small group instruction. John was a member of the university's lacrosse team, and participated in that sport in high school. He alluded to that participation as a source for his confidence in the classroom. When asked about his confidence in teaching at the junior or senior high school levels on the student questionnaire, he indicated that he felt confident in his ability to teach at either level.
Coming from a large high school, he had a different teacher for each of his mathematics and computer science courses. His mathematics teachers favorably impressed him, with two having an impact on the manner in which John perceived mathematics and how a classroom should be conducted. When asked about these teachers, John thought they "definitely shaped how I thought about mathematics." However, the primary ideas reported by John on how those teachers affected him were the organizational skills of his eighth-grade teacher and the professional dedication and ability to always encourage students of his precalculus teacher. No mention was made about their approaches to teaching mathematics.

**Incoming Experiences and Beliefs Concerning the Secondary School Mathematics Classroom.**

John entered the mathematics education program without having a single influential teacher after whom he planned to model his own teaching. However, the cumulative effect of his prior experiences caused John to believe he would teach in a manner similar to his prior secondary school teachers. His preconceptions about his role in conducting discussions is reported in the seven categories.

**Category 1: Flow of Ideas**

John's experiences in secondary school are typical of those described in the literature (Goodlad, 1983). His teacher would "give us the ideas." When asked to describe what his teachers did in full-class situations similar to Scenario 2, John said:

They probably would set up the problem, start it, and they say, "What do I do next. What's the next step? We have this method of doing this problem, what do I do next now?" That's pretty much how it went.
John reported that he would do the same thing. If he were going to give a lesson in algebra, he would "do a lot of talking at the beginning, just to give them the basic facts." The picture that John painted of how he would teach as he entered the program indicated a pattern of talk in mathematics classrooms that would begin with factual information and procedures. He described a mathematics discussion in the following terms:

Math discussions are just not like anything you've ever heard. People talking about numbers and theorems. It just sounds like a really weird discussion. If someone were to come in on some piece of literature, you could kind of ease your way into the conversation. But if you come into a discussion of Pascal's Triangle, you're like... Why are you even talking about this. Yet, you have to know what you're talking about. If you don't know what you're talking about, you can't talk about math. In math it's concrete, it's either black or white, most of the time.

For John, there's not much to say if you don't have the "facts". It seems that for John, participation in classroom discussions originated out of a position of knowledge. His knowledge of the "facts" is one of the reasons that John felt more comfortable in mathematics classes than in other classes.

Yet, John is not comfortable with just giving students the "facts". As he stated:

I think that as a teacher, there's got to be a point where you let the class learn for themselves, and if you're always just feeding them knowledge, that's not going to work. You've got to be comfortable with letting them experience it on their own. And I'd be real comfortable doing that because it works so well for me.

It seems then that John valued the ability to figure things out, but still sees mathematics as something that is black and white.

**Category 2: Student/Student and Teacher/Student Interaction**

John reported that he infrequently worked in small groups; stating that he hardly ever participated in student/student discussions similar to those
depicted in the first scenario in the screening questionnaire. When John's teachers did have the students break up in small groups, their behavior included circulating among the groups to make sure that everyone was on task and helping students "get on the right path." They also spent time at their desks doing their administrative work or as John called it "other stuff to do."

John's perceptions of his experiences in small group situations in mathematics class are interesting. He had benefited from working with students of equal ability, learning from one another. In opposition to this experience, John reported that he often would be the one that the rest of the group would look to in order to solve the problem. When asked under what conditions would he use small group instruction, he expressed that the complexity of the problem would dictate the necessity of small groups. He would not use small groups for:

Things that are simple. Like say you're working with basic algebra, x+5=7. You don't need people to work together on stuff like that. It really doesn't require a lot of thought, it's kind of more of a method that you have to apply.

It seemed to John that one aspect of small groups was to provide a place to solve problems collaboratively. When asked if he would employ small groups in instruction, he felt that it depended on the unit. "Something that was just rudimentary; that you could teach them a method and then they could do it." He expressed concern that students do not stay focused in small groups, talking about social concerns and not the mathematics to be learned.

Full-class discussions in John's experience were in a recitation or guided discussion format. The majority of verbal interactions that took place in John's secondary school mathematics classes while teaching mathematical
content were teacher/student interactions. Students were asked questions, responses were made by the student and the teacher interpreted the responses, and moved on to the next student. When describing Scenario 2, John said that a former high school teacher ran her classroom in almost the exact same way, and that there was nothing about the scenario that he had not experienced before.

In rating the effectiveness of Scenario 2, a recitation that reviewed problem-solving steps, John felt that some students were intimidated by situations similar to the scenario and would benefit from having a small group in which to discuss the ideas in the lesson. However, he felt it was ineffective:

Probably because most people still had questions when we talked in large groups. And they wouldn't always bring them up to the teacher. We would get out of class and people would say, man that's confusing me. But they wouldn't ask in class, because it's a big group. But I think if they're in small groups they wouldn't be as intimidated.

This belief was illustrated by John's intended behavior as a classroom teacher. When asked why he would use small groups in instruction, he responded that he would utilize them "to help stimulate their minds, or maybe to be able to think more clearly about a problem after someone else gives them some input." This idea correlates well with John's belief that students have to learn for themselves at some point in time, that teachers can't always be just feeding students knowledge.

Even though John saw the need to have students verbalize their thoughts, he said that he would use the tactics in Scenario 2, since it had been effective for him. In describing how he would teach a hypothetical mathematics class, he said:
Say I started a unit on algebra or something, I would do a lot of talking at the beginning, just to give them the basic facts. Then as we got into more applications, I would want them to explain to me how they can apply it. So first, I would want the students to talk a lot. Just so they know why they are doing it, and exactly what they are doing. I mean, I could sit in a class for two weeks and not understand a thing, but if I have to tell you what I'm learning, then you have no choice. Because you have to verbalize it, and no one wants to look like an idiot in front of their classmates.

John seems to have formulated a progression for the interactions that take place when students learn mathematical concepts. First the teacher lectures. Then students apply what they have learned and explain how they do that. Finally, they are asked to verbalize the concepts that they have learned to themselves and others. This final stage of verbalization leads into the third category.

**Category 3: Students Justify Their Ideas**

An idea one of his teachers communicated, and that John keyed into, was the need for students to express their understanding of concepts verbally; something that being in a small group facilitated. A conclusion that John made about his own teacher's actions was illustrated in his comments:

Because my teacher thought that if you could talk to someone about (what you thought about a problem) and tell them what you were doing, if you could explain why you were doing it to someone, it would help out a lot.

John had interpreted his teachers intentions about the times when his teachers had put him into small groups during class.

John recognized that justifying his understanding of concepts to himself as well as to others was an aspect of his learning style. This metacognitive practice demonstrates the value that John put on being able to clarify your thinking. He described this practice as:
I think that if I can verbalize what I'm thinking in my head, I learn a lot more quickly. Like if I'm in my room and I'm having trouble with a problem, I'll start talking about it to myself. I'll say what the problem is. I'll read the problem out loud so I can hear what they're saying, like what the questions asking. I'll try to talk it out, I'll say what if I did this, or what if...Talking to myself.

By talking to himself, John illustrates a personal acceptance of what he perceived his teachers stressed in class.

**Category 4: Acceptance of Ideas**

John's responses to the parts of Scenario 2 help see some of the experiences and ideas he had about this aspect of teaching. Two parts of the scenario deal with teacher praise and response to alternative methods of solving problems. John's reported classroom experiences reflected a more "traditional" approach in which answers were evaluated for correctness and the teacher/student interactions continued until the right answer was determined. In explaining what his teachers did when a student gave an answer, he said:

If (the answer) was correct, they would say that's real good. It seems like you're learning. If it was wrong, they would say, "Well." Then they would go on to another answer and then go back to the person who got the wrong answer, and say, "Do you understand how they got it." So it wasn't like, if you got a wrong answer they would put you down. Say, like, "That's horrible, how could you give me an answer like that." But they would go back to that person and say, "Do you understand how she got this answer instead of the answer you had?" And if they didn't, then they would go back and explain it to the person who didn't get the right answer.

Even though John's teachers exhibited a desire to help students develop understanding, a premium was still placed on having the "right" answer. When asked what he would do in similar situations, John expressed that he would do "pretty much the same thing."
In response to alternative methods of solving problems, John reported that his teachers generally steered the discussion back toward the recommended problem-solving steps. He stated that his teachers would say "That's good, but this is how we do (the problem)." John didn't leave much room for originality in the mathematics classroom. When asked how he would respond to students who introduced an alternative method to solving a problem, he said:

Usually what happens is it might just work for that case, or something like that. Or even if it works for all cases, sometimes. I know like in the past, you'd say this is how I did it, and it was a lot shorter and a lot easier, but if you tried it on a harder example, or with bigger numbers or something, the method that was easier before becomes, well, like you could get lost pretty easily. So I would tell them to learn the actual method and if their method can apply, go ahead and use it. It's valuable to have that independent thinking, but also know the way that we want, the curriculum says that you should learn it.

John's response reveals a strong tendency toward seeing mathematics as something that is right or wrong. John commented further that mathematics was not all black and white as commented before; that gray did come in through the different methods that a problem could be done. However, John pictures himself as a methodical person, saying "If someone tells me a way to do something, I stick to that and do it that way. Independent thinking is good, but I like to have everything concrete."

Category 5: Tasks that Promote Discussion

John had formulated a hierarchy of tasks for the mathematics class. For lower level tasks, such as solving a basic algebra equation like $x+5=7$, John felt that students did not need to work cooperatively. In response to a question about situations in which he would not have students work in groups, John responded:
You don't need people to work together on stuff like that. It really doesn't require a lot of thought, it's kind of more of a method that you have to apply.

As expressed earlier, he said that he would have students work in groups with more challenging problems. Such situations seemed to be more appropriate for small group instruction. It seems that to John, small groups become appropriate out of necessity to do a problem, not to learn a concept. There seems to be a procedural orientation to John's responses. Groups become necessary to perform the task, not necessarily to understand the concept. Therefore, only difficult tasks would be chosen to engage students in interstudent discussion.

**Category 6: Teacher Intervention in Problem Solving**

The teacher in Scenario I helped a student by suggesting that the students try numbers. When asked what his teachers tended to do when students got stuck, John said that his teachers tended to get the students going by first doing a similar problem and then having the students follow up with another one similar to it. John was able to distinguish this from actually doing the problem. His experience as a tutor convinced him that just giving the answer made the students dependent on him for the answer. He felt that it was better to give hints in order to get the students thinking for themselves.

He stated:

> I think that as a teacher, there's got to be a point where you let the class learn it for themselves, and if you're always just feeding them knowledge, that's not going to work. You've got to be comfortable with letting them experience it on their own. And I'd be real comfortable doing that because it works so well for me.

John has concluded that students learn best from working it out for themselves. However, that doesn't yet mean that the students will completely construct their own knowledge, because John still felt that he
would act in much the same way as his teachers by "seeing if they started on the right track."

**Category 7: Orchestrating the Discussion**

John's account of his experiences indicated that his teachers followed a traditional approach to classroom communication. He described his classes as being "kind of a question and answer thing." A typical exchange between students and teacher during classroom work on word problems was given as:

They probably would set up the problem, started it, and then say what do I do next. What's the next step? We have this method of doing this problem, what do I do next now. That's pretty much how it went.

As already stated, John's teachers were concerned with the why of the students' answers, but it still seemed that the teachers were looking for the "right" why for any given aspect of the problem. The theme of having right answers surfaced frequently in John's accounts of his experiences.

John's view of his role in orchestrating classroom discussions was self-described as similar to that of his teachers. He, too, saw himself as the person who would guide the students toward the correct answers through astute questioning. Expressions that John used to describe what he saw himself doing in the classroom in small or large group settings were: "clarify my point," "make sure they were doing it correctly," "talking at the beginning," "help them out," and "think of questions someone might ask." These expressions have an undertone of the teacher who shows the student the right method and checks to see if they have mastered that method.

In describing his role as a tutor for a GED program, John expressed that he took a very active role. He stated that:

I essentially taught them from base one exactly how to do it. Exactly how to add two numbers. Exactly how to multiply two by two's, and then they would ask me questions, like what if I had extra. They'd ask me the
question if you have to carry. So I would wait for them to question what they were doing, and then I would answer their questions.

His experience as a tutor illustrated his approach to teaching in general: Show the kids what to do, give them a chance to do it, and then answer their questions when they do it wrong.

**Summary of John's Preconceptions about His Role in Classroom Discussion**

John's responses confirmed what the literature says concerning the influence of prior experiences on preservice teachers preconceptions about teaching mathematics. John often responded that he would do things as his teachers did them.

John's perspective about teaching mathematics involves his concerns for the students as people. He praised his teacher that cared about her students and always encouraged them, and carries that concern into his perceived role as a teacher. His ability to understand what was going on in mathematics class gave him the confidence to speak up in class. Consequently, John would like to cultivate that same confidence in his students by not putting them down in class for having wrong answers. John's preconceptions about his role in discussions are summarized in the seven categories.

**Flow of Ideas.** John's secondary school mathematics classes resembled those described by Goodlad (1983) in which the teacher "gives" the students the ideas. John felt he would start out lessons by giving the students the basic facts. This belief was counterbalanced by a desire to let students learn for themselves, recognizing that just feeding the student information will not work.

**Student/Student and Teacher/Student Interactions.** John had little opportunity to work in small groups in secondary school. Although he expressed a willingness to use them to promote collaborative problem
solving, he felt small groups unnecessary for learning mathematical procedures. John felt he would utilize teacher-centered methods of his former teachers who engaged students in a recitation or guided discovery format of conducting discussions.

**Students Justify Their Ideas.** John expressed a belief of one of his former teachers that students needed to express their understanding of mathematics concepts verbally. An important part of his learning style, John believed he would have his students justify their ideas.

**Acceptance of Ideas.** John's former teachers placed a premium on the correctness of students' answers when presented in the classroom. John indicated he would be accepting of students' ideas and appreciated students' creativity, but would steer students towards the preferred method expressed in the curriculum, a preference he had in his own learning.

**Tasks that Promote Discussion.** John expressed a hierarchy in choosing tasks for the mathematics class. Procedural tasks could be done individually, but more difficult tasks required more collaboration. For John, tasks were not chosen to promote discussion, discussion was needed depending on the task.

**Teacher Intervention in Problem Solving.** John believed just giving students answers was not appropriate when students get stuck. Instead, John preferred to give hints that would get the students thinking for themselves.

**Orchestrating Discussions.** John's primary method of orchestrating discussions is to get the students on the right track. His approach was procedural in nature, show the students how to do it, let them try to do it themselves, and then lead them to the correct method through leading questions if they do not understand. John felt he would teach in a manner similar to his own teachers.
In general, John sees the role of the teacher as the moderator who leads the discussions, and as a middle man who fills in the blanks to students with a lot of the answers. He called the teacher a "fill in the blank man." This gives the impression of the teacher as the one who has the knowledge that the students must master, and who asks questions that allow students to fill in the parts that are not understood.

**Perceptions of His Role in Discussion After Participation in the Mathematics Methods Course and Related Field Experience.**

John was an active participant in the methods course. He frequently made contributions to the discussions held during the methods class instruction. His view of the methods class, however, was that the material covered there seemed to him to be common sense. When asked to give an example of a common sense notion covered in the class, John referred to the idea of lesson plans. He did not identify any direct effects that the methods class had on the way he perceived his role in classroom discussion in that the ideas presented seemed to be consistent with the ideas that he had when he came into the program. This, perhaps, is due to the fact that the methods instructor chose to model appropriate behavior in discussion, rather than make it a specific topic covered in the syllabus. John did acknowledge the professor's efforts to model teaching behavior, remembering several occasions when the professor asked what she had just modeled for the students.

John's field experience was in a third grade classroom in a suburban school district close to the university. The cooperating teacher was a relatively new teacher, but had supervised preservice teachers before. Of all the field placements during the first quarter, John's was the most conducive
to teaching mathematics concepts to the entire class as well as providing opportunities to have the students work in small group settings. Activity centers were held each day in which students broke up into groups to cover different subjects, one of which was mathematics. John was given the responsibility of developing mathematics activities to do with the students. John also had the opportunity to teach different concepts to the entire class during the mathematics lesson. During these full-class lessons, John's cooperating teacher made an effort to identify aspects of his lesson presentation that needed improvement. She and John would identify a given teaching skill and discuss how well John incorporated that skill into his lessons.

The university supervisor interacted with John concerning his field experience by observing his activities, responding to his lessons, and reading his field journal. John reported, however, that this contact had minimal influence on the way he perceived his teaching, and stressed that his in depth interactions with the cooperating teacher concentrating on individual teaching skills was much more influential.

**Category 1: Flow of Ideas**

John's very first statement in his field journal was, "I am the one with all the answers for these impressionable youngsters. It is such a crazy feeling." That comment verbalized what most preservice teachers are thinking the first time they enter the classroom. They are the ones with all the knowledge their students will need to learn. That statement, however, does not determine how the preservice teacher will present ideas in the classroom.
John demonstrated a mixture of how ideas were to be presented in the classroom. Several activities that he organized for the small groups indicated that John wanted students to have open-ended questions that allow students to explore on their own. In his first planned activity, he drew upon his own interest in making necklaces to have the children make necklaces with student-made patterns using three kinds of pasta. Another small group activity he organized involved problem solving with tangrams. He had the students come up with different ways to make given shapes using a certain number of the tangram pieces.

However, John was very structured when it came to presenting whole class lessons. His approach to these lessons was that there was a certain idea the students needed to know, and he would present explanations and experiences enabling the students to understand that idea. His lessons on fact families illustrates this point. At first he presented the idea in lecture form, and was frustrated when the students didn't understand. He followed up the next day with a lesson using manipulatives and a game to go over the concept. His presentation of the ideas, even down to the manipulative use, illustrated that the ideas were originating with the teacher. This excerpt from the lesson illustrates that point:

There's one more thing that we have to do this time when we're using our blocks. Usually, when we use the blocks, it doesn't matter what colors are together, but this time it's going to be real important that we keep the colors all together. So, if you have six green blocks, the six green blocks have to be together all at the same time. That's going to help you create your fact family. Manipulatives were used to embody the concept, but the students were not first given the chance to discover that relationship for themselves, the teacher showed how it was done first, and the students imitated the teacher.
Category 2: Student/Student and Teacher/Student Interaction

John had several opportunities to experience, observe, initiate different levels of student/student and teacher/student interactions. Many of the methods class activities involved discussion that were directed by the students. The methods instructor gave the students group assignments, the results of which students presented to the class. Time constraints disallowed students from engaging in the activities they had prepared. While presenting activities from journal articles related to different curriculum concepts, the class participated in open discussion that allowed for a free exchange of ideas. During these discussions the methods instructor modeled a non-intervention technique of wearing dark glasses, hoping that hiding her eyes would free the students from seeking her approval. John perceived the methods instructor as a good role model for conducting student discussions. He stated that she was:

a good example of what a teacher would want to do in the classroom in leading discussion. Not being the sole talker. Putting forth an idea and letting the students discuss it. And then if we went astray to get us back on path.

John was hesitant to say that this changed his approach to discussion, still believing that this was common sense.

The small group activities in John's field experience were characterized by the cooperating teacher as situations in which students relied on each other for ideas and confirmation. However, John saw that the activities that he directed were more for practice than discussion. In his description of the small groups he said that:

It was more of an activity table where I would explain it and they would do it. And then if they had questions, then we would discuss it. But it wasn't like come over here and we're going to discuss place value.
This situation presented a dilemma for John, because although he acknowledged that little interstudent discussion took place during the small group activities, this was one area that he felt warranted change. He stated that he would definitely attempt to incorporate groups into his next level of teaching, looking for activities that were conducive to that end.

**Category 3: Students Justify Their Ideas**

One area of discussion that was emphasized in every level of John's experience was having students explain their answers. The question of asking why students respond as they do became affectionately called the "why" question. Even when John talked about explaining a concept to the class, he still expressed the fact that he would want to have students explain their answer. He said that:

> rather than say, "OK, what's the answer to number 8? What's the answer to number 2? (He would say) "Why is that five?" To make them think.

This tendency to ask the students to justify their answer was noted by the cooperating teacher. She noted a distinct evolution in John's lessons in which:

> progressively he came around to having written lesson plans similar to mine that are kind of short. And allowing more for why. What makes you think that? How else can we do it? And I think, I don't know if that was from him watching me, or it was from him becoming more confident with the kids.

In fact, the cooperating teacher did recount that she and John had indeed made asking questions requiring students to explain their answers a priority.

Even this question though was concerned more with the student justifying to the teacher why an answer was correct or incorrect, and less toward students convincing one another of their ideas. John even recognized
this from a comment made in his journal about having the students come to
the board to explain their answers.

Each student's explanation was virtually the same, but I think having to
say why to the whole class helped the students comprehend the concept
better.

It seemed to John that scripted explanations are better than no explanations.
In fact, transcripts of John's lessons indicated that students at the board did
tend to give the same explanation.

**Category 4: Acceptance of Ideas**

The acceptance of ideas is crucial to creating an atmosphere in which
students feel free to express themselves without condemnation. The
cooperating teacher expressed that idea in acknowledging that students do not
like to hear the word no. John was also sensitive to students' feelings about
themselves and made conscious efforts to acknowledge students' answers in a
positive way. This normally meant that John would respond to an answer
with words like "good," "excellent," "Okay." In a typical exchange during one
lesson, John asked a question, the student responded and then John
evaluated the response. This teacher/student/teacher interaction was the
mainstay of classroom discussion. It did, however, establish the pattern that
the teacher was the one who evaluates the answers and determines its
correctness. At no time during the large class discussions did John deviate
from that pattern.

John did see the benefit of having other students become involved, as
evidenced by his comments in his field journal. As students were asked to
classify geometric figures hidden in a bag, he remarked:

That was where I could see the students learn. I had the students who
knew it was a rectangle tell those who didn't believe it was indeed a
rectangle, exactly why it was a rectangle.
Although he elicited the input of other students, it was still clear that the right answer was what the class was after, not the explanation of what the person was thinking. Acceptance of answers was not left up to the individuals, but imposed from an exterior source.

**Category 5: Tasks that Promote Discussion**

The job of the teacher of choosing tasks to promote learning and influence the nature of discussions in the classroom is one for which John exhibited a significant amount of change during his participation in the methods class and field experiences this quarter. The change was influenced to a large extent by his exposure to new ideas in the methods class and the reinforcement of these ideas in the field experience.

One area that had an impact on John was the use of manipulatives. The methods instructor stressed their use and the positive effects on learning they have in the methods class. When asked what influenced him the most in making changes in his approach to teaching, John responded:

Realizing concrete examples help and are important to help a student understand things better.

This belief was reinforced by John's experience in the classroom in many ways. The cooperating teacher used manipulatives in teaching students about place value. She used counters and the saying "scoop them up and put them in the cup" to help students understand about the tens unit. John was impressed by this idea and used it in subsequent lessons. A lesson near Halloween that impressed John incorporated candy and the seeds in different sized pumpkins to illustrate graphing and categorization principles. After the morning of mathematics activities, the class didn't realize they had been doing mathematics. John recounted in his journal:
At the end of the activity the cooperating teacher asked the students if they enjoyed their math lesson for the day. I heard some students mumble that they didn't remember having a math lesson, and then one student spoke up. "You tricked us." The cooperating teacher asked the class, "Can math be fun?" The whole class cheered a resounding "yes."

John expressed the desire to make his classes a place that students want to come to because they could never know what to expect next, a place where they could have fun.

John experienced a situation in which he used manipulatives in a follow-up lesson on fact families after an initial lesson was unsuccessful. Unifix cubes were used to demonstrate fact families having a total of 10. Students were given the cubes and asked to determine the fact family illustrated by the cubes. This helped the students visualize the concept, but the ensuing classroom discussion was more of a recitation than a discussion. In this instance, the use of manipulatives had not altered the way John led the discussion.

A second tool that could possibly alter the way in which discussions unfold is the calculator. This was strongly emphasized in the methods class, and an idea that John picked up on. He was enthusiastic about the possibility of using calculators in class, and described a lesson in which students would be allowed to explore relationships using multiple examples generated on the calculator. The calculator, however, was not used as a classroom tool in his field experience, and without the initiative of the cooperating teacher, John did not introduce any activities with its use.

A third type of task that John responded to favorably was student journals. Introduced in the methods class and encountered in selected readings, John liked the idea of having students keep journals. He felt that they offered a good medium to help student understand concepts. He had
also formulated ideas about how to use them. When asked how journals could influence discussion, he replied:

After reading them, if I found there were topics or points that people were making that I thought the whole class might need to know or there was confusion, then we could discuss the confusion, we could discuss what's happening.

He was convinced that he would use them in his own classroom.

**Category 6: Teacher Intervention in Problem Solving**

John did make some interesting observations about when to intervene in problem solving situations, and how that would impact the discussions in the classroom. One of the things that he consciously worked on during the quarter was letting students struggle with a problem. He recounted that:

The first couple of times I taught I would give them an answer or give them a clue right away, but I learned to wait and let them figure it out by themselves.

In one of his journal entries he wrote:

In my opinion, it is better for them to try haphazardly than for me to give them clues and hints as to how to solve the problem, because it makes them think for themselves....Rather than relying on me for the answer, they should develop the ability to look within for a solution.

John made the connection that allowing time for students to try for themselves influences the responses students give. He said that, "One thing I learned is that the more patience I show with the kids, the better they respond to me."

**Category 7: Orchestrating the Discussion**

John initially came into the program thinking that classroom discussion meant that he would "be up in front of the classroom," saying this is how you do it. Through his experiences in the first quarter of his studies, this picture changed. In his own words, he realized that:
the teacher doesn't have to do as much, if you have faith in your class and you have faith that they're there to learn. The teacher doesn't have to do much. Like the methods instructor did, guide it. You don't have to run it, you don't have to be the leader of the discussion. You have to be a secondary person sitting there letting the students interact, rather than always looking to the teacher for the answer. What does the teacher want to hear? I wouldn't want to create that situation.

John went from assuming that he would do all the talking in class to being concerned about not creating an environment where he did all the talking. This change took place for several reasons.

First, being assigned to a cooperating teacher who evaluated his teaching for areas on which he needed to work, helped John become reflective about his behavior while teaching. John and the cooperating teacher worked on not calling on only the children who had answers, not repeating answers given by students, asking students to explain their answers, and wait time. Of all the techniques that the literature proposes for enhancing discussions, the one given most attention by John was wait time. The technique was presented in the methods class, modeled by the methods class professor, identified by the cooperating teacher as a skill that John should work on, reinforced by the university supervisor, and cited by John as a technique on which he worked. This unified treatment of that technique helped solidify its use in John's teaching.

Second, John had many opportunities to teach under careful supervision. Although only in the class for 14 days, he taught 5 lessons to small groups and 4 lessons to the entire class that he had prepared for himself. In the 2-day lesson on fact families, he was able to adjust the lesson the second day in order to compensate for weak points of the lesson from the first day. The introduction of manipulatives on the second day reinforced the
importance of having the concept represented in several different ways in order to reach the greatest number of learners.

Analysis of his lessons indicated that although John desired a classroom in which he did much less of the talking and students did more of the talking, he had not arrived at reaching that type of role in the discussion. In fact, John's full-class lessons often took the form of a recitation in which students were asked to give factual answers. An example of his teaching reveals this observation:

John: So, there's two addition problems and there's two subtraction. I'm going to give you an example with these cubes here to show you exactly what you do. I have 14 cubes in my hand. 1,2,3,4,5 white ones, and 6,7,8,9,10,11,12,13,14. 14 total. Five of them are white and 9 of them are red. So one of the numbers in my fact family is going to be 14. OK, 14 blocks total. Then another number in my fact family is going to be how much, Matt?

Matt: Five.

John: Five. That's the white block. Who can tell me the third number in my fact family? Jeff?

Jeff: Uhm, nine.

John: Good. All right. I'm going to use these three numbers and I'm going to have two addition problems. Two number sentences with addition and then two number sentences with subtraction. And who can tell me one of the ones for addition? Anthony?

As this excerpt demonstrates, John does most of the talking and the questions are typical of fact finding questions. This exchange was typical of how John led discussions with the large group. If his goal was to do less of the talking, these excerpts illustrate that he was far from that goal, and the lack of feedback from the supervisors about that point indicate that he was not challenged to change that aspect of his discussions when in front of the whole class.

When asked to estimate how much time he spent in lecturing, questioning, and letting the students explore concepts on their own, he reported that 50% of his time was spent in questioning. The type of
questioning illustrated here indicates that John spends a lot of time in a recitation mode while teaching the full class. Despite using tools that can encourage students to present and justify their ideas, John's approach to discussion still reflects a predominance of teacher/student interactions oriented toward getting at the facts.

**Summary of John's Beliefs and Behaviors after the First Quarter**

A picture begins to emerge of John's beliefs and behavior concerning his role in classroom after first quarter in the teacher education program indicated that changes were taking place in his perception of how discussions should be conducted. John started with a relatively naive picture of what a teacher does based on his past experiences as a student in college, secondary school, and elementary school. That picture included him in front of the classroom, explaining concepts to students. As he was exposed to new ideas in the methods class and as he had the opportunity to teach some concepts on his own, that picture began to change. The changes are summarized in the seven categories.

**Flow of Ideas.** John's expressed beliefs about the direction from which ideas should flow changed during the quarter, but his behavior manifested the change in some circumstances and not others. When working with small groups, John developed activities that allowed students to explore ideas on their own. However, large-class discussions generally focused on a teacher-centered presentation of ideas.

**Student/Student and Teacher/Student Interactions.** In both the methods class and the field experience, John observed discussions organized to promote communication between students. The cooperating teacher sometimes wore dark glasses to force students to listen to and talk with each
other. However, discussion organized by John in the field experience tended to be teacher-dominated, despite John's expressed beliefs of wanting to promote more student/student interaction.

**Students Justify Their Ideas.** John's preconception of having students justify their ideas was reinforced by the methods instructor and the cooperating teacher. The methods instructor stressed the use of the "why" question in order to encourage students to justify their ideas, and the cooperating teacher made having students justify their ideas a priority in the class. John asked students to justify their answers, but often received only the scripted justification based on rules devised in the class, a fact John felt was better than not having students justify their responses at all.

**Acceptance of Ideas.** John's preconceptions indicated he would be accepting of students' ideas, but would steer them towards the correct answer. This belief was manifested in the field experience where John generally responded to a student's response with some form of approval, then directing the discussion toward the correct answer.

**Tasks that Promote Discussion.** Exposure to many new ideas in the methods instruction helped develop a new dimension in John's beliefs about teaching and conducting discussions. The three most influential were the use of manipulatives, calculators, and student journals. The use of manipulatives in the field experience reinforced John's belief in their importance for helping students understand mathematical concepts. He personally experienced their effectiveness in one lesson on arithmetic fact families. John saw how calculators could be used to allow students to explore concepts by producing multiple examples of a concept, and that student journals could be used to identify and discuss students' points of confusion. But because the use of
calculators and student journal was introduced in the methods class, but not modeled in the field experience, John was able to only express his intentions to utilize them in his own teaching.

**Teacher Intervention in Problem Solving.** John's beliefs about intervening in students' behalf developed as a result of monitoring his own teaching. He noticed with the help of the cooperating teacher that by not giving the students clues too quickly, the students often figured the problem out by themselves. He felt it was better to let the students try for themselves, even if only haphazardly, in order to make them think.

**Orchestrating the Discussion.** John moved from believing that he would be up in front of the classroom to realizing the teacher doesn't have to do all the talking. The cooperating teacher pointed out specific behaviors that affected how discussions unfolded in the classroom, and worked with John on changing his behavior. Among these was not calling on only students with answers, not repeating answers, and wait time. John had ample opportunity to teach, giving him sufficient time to see progress in his teaching. Although John's expressed beliefs indicate his willingness to have a student-centered class, his behaviors in large class discussions continued to reflect a predominance of teacher/student interactions oriented toward factual information.

John demonstrated that he was open to new ideas. This openness allowed him to try to implement most of the new ideas that he received from the methods class professor and the cooperating teacher. It was helpful that he saw no conflict between what was being proposed by the different components of his experience. A second aspect of his openness was that John saw most of what was being suggested as common sense. Significant changes
were made in John's expressed beliefs about his role in conducting discussions as a result of the methods instruction and field experiences. However, a gap existed in the agreement between those beliefs and observed behaviors at the end of the first quarter.

**Perceptions of His Role in Discussion After Participation in the General Methods Class and Related Field Experience.**

The second quarter of studies in John's program called for participation in the general methods class and a mathematics field experience. The mathematics field experience consisted of a 2-day per week placement in a sixth-grade class in an urban middle school in the same community as the university. The racial mixture of the was 50% African American and 50% white. The cooperating teacher had been in teaching for eight years and had supervised preservice teachers on several other occasions. The cooperating teacher had only recently become aware of calculator use in the classroom as a result of a course he took at the university and was part of an inservice project to teach discovery methods of learning mathematics. This indicated he was also in the process of refining his mathematics teaching methods.

The field experiences were altered during the quarter due to a scheduling conflict with John's varsity athletic participation. With mutual agreement by the cooperating teacher and the university, John went to the school each morning for two classes, the first a study hall for the students and the second a sixth-grade mathematics class. John took over the teaching of the second period class and taught the students a unit on geometry during the final eight weeks of the quarter. This constituted a major difference between John's experiences and those of the other students in his cohort.

The contributions of these experiences to John's development are included in the descriptions of the seven categories.
Category 1: Flow of Ideas

The manner in which ideas are presented in John's classroom were sometimes in conflict with the manner in which John would like to see them presented. Ideally, John would have liked to do more exploratory activities with the students, in which the students would interact with one another while solving a problem. John expressed the desire to let the circumstances determine how he would respond to the learning needs of the students. In describing his lesson plans, he wrote in his journal that he plots a general outline of the lesson, because he likes to leave himself some freedom to see what happens in class and make decisions based on the students responses.

John would like to see ideas presented out of problem-solving situations. This preference was also expressed by the cooperating teacher and the university professor in charge of the field experience, and reflects the instruction that John received in the methods course during the first quarter. His fellow students agreed with this approach as evidenced in many of the comments made during the seminar discussions about the Standards. One student's cooperating teacher started the class each day with problem solving, engaging the students in cooperative exploration.

John, however, did not always illustrate this type of teaching. For the most part, his lessons started with an explanation, usually providing definitions for the concepts to be mastered, followed by activities to clarify the concept. John was creative in coming up with activities to challenge students to integrate the topics of the explanations into their own experience and to allow students to come up with ideas of their own. In one activity, John asked students to incorporate the four categories of angles they had studied into a drawing of their choice. This was an effective exercise that tied into
their daily lives and enabled students to use their own creativity. Examples of students' work included a car and a pencil, demonstrating to the students there was not always one right answer to a given problem.

John did not just give the students information, believing it necessary to get the students involved. This took the shape of classroom discussions in which John posed questions to elicit student knowledge. In general, the direction of the ideas to be mastered come from the teacher to the student, and not from student responses to learning situations.

Category 2: Student/Student and Teacher/Student Interaction

After finishing the first quarter, John intended to employ cooperative learning situations more frequently in his classes to generate student/student interactions. This idea was reinforced by his cooperating teacher, who had small group problem-solving activities during his first week of observation. The general methods class instructor modeled this kind of behavior in class. The students of the methods class were often asked to work cooperatively on a task, a fact that impressed John. He felt that he benefited greatly from those experiences. John did organize several small group activities in his class during the quarter. One such example was an activity in which students worked together with tangram pieces to create various shaped polygons. Another opportunity was offered to the students in which students worked together to perform translations of one trapezoid on a coordinate grid.

These activities were the exception for the quarter. Most of the verbal interaction in the classroom was teacher/student. One way to picture this type of interaction is the image of a tennis match with the teacher on one side and a student or a line of students taking each volley from the teacher. John's discussions resembled this image often classified as recitation. John posed
questions, responses were made by students, John would evaluate the response, and usually attempt to lead the student to reevaluate their response through a series of questions, or move on to another student. An example of this type of dialogue is:

John: OK, we need to make two rays and that will give us an angle. Let's start by making, well, we need the ray to start at one point, and then we'll draw a ray to start off with. Let's label that ray AB. We're going to need to have a vertex of A, and from that vertex, we're gonna draw a ray AB. Right here. Does everyone see that? Who knows what I should do next? Does anyone have any idea? Jamel?

Jamel: Make a ray going up.
John: What's that?
Jamel: Make a ray going up.
John: A ray going up. Well, where's the ray going to have to go through? Well we want to make something that's 85 degrees, right?

Jamel: Between 80 and 70.
John: Between 80 and 70? Well is 85 more or less than 70?
Jamel: More.
John: OK.
Jamel: I mean, between 80 and 90.

Even though this exchange took place while John was teaching students the skill of how to use a protractor, it captures John's general mode of conducting classroom discussions. John took great care to draw as much out of the student as possible before going on to another student. There were several times during this exchange where other teachers would have moved on to another student, but John gave each student as many opportunities as possible to understand the concept under discussion.

This contrasts the image of discussions as a volleyball match in which the teacher sends a question to the students, who bounce their ideas around, before the teacher intervenes again to assess the progress of the discussion. John characterized his role in this type of discussion as that of a facilitator, as
modeled by the methods instructor in the methods class. He admits however, that this kind of discussion did not come about that often. One of the reasons he gave for this is that the level of the students did not permit the open exchanged that he saw in the methods classes. He said, "They get a little out of control telling each other they're wrong and telling each other that they're stupid, so that's where you have to lead the discussion back to where it was." John seems to accept the volleyball image of discussion as an ideal, but has yet to consistently put it into practice.

**Category 3: Students Justify Their Ideas**

John held the importance of having students justify their ideas during discussion when he entered the program, maintained it through the first quarter, and continued to develop it throughout the second quarter. John wrote in the journal about how he felt when his students seemed to be able to justify what a translation was.

When I asked the students why they were doing what they were doing, they responded, "It's a slide down, up, to the right, or to the left." It was quite rewarding to hear their response. John felt that asking students the why question promoted the most learning in his classroom.

In fact John considered himself an emissary of the idea to the cooperating teacher. This was not the imaginings of a self-promoting undergraduate. Both John and his cooperating teacher considered John's asking his students to justify their responses as exemplary. John recounted in the mathematics field experience seminars that his cooperating teacher rarely asked why when addressing students and that:

He was more like, "how do we do this?" How? Not why. He would stress the how but what was good I think, it made me feel really good is
at the end the last couple days, I observed him and he started asking why are we going to do this?

The cooperating teacher said "I've found myself asking the question why a lot more than I ever did before."

Seminar discussion also stressed the importance of indoctrinating the students to being required to justify their answers. The students concluded that asking students for clarification even when the response is correct is important. Many teachers indoctrinate their students into believing that if they are asked to justify their response, it must be wrong. One of the students recounted how her students no longer panicked when asked for a justification, because they realized that being asked that question did not equate to a faulty answer, an idea with which John agreed.

**Category 4: Acceptance of Ideas**

In his general method class field experience report on his visit to the high school, John noted that the teacher praised those students who gave correct answers. Although praise and positive reinforcement are important, praising correct answers reinforces the idea that mathematics is a rigid discipline, made up of correct answers that you find, not a process of making sense out of the world around through mathematical concepts.

John and his fellow classmates noted that the teacher should not be perceived as the one with the right answer. They agree with the *Standards* viewpoint that the students should be encouraged to disagree, even with the teacher. One way the preservice teachers thought would encourage students to disagree with the teacher was for the teacher to make calculated mistakes. When some of the preservice teachers in the seminar were skeptical that students pay attention to that, John reported having used this technique effectively in his class.
I don't agree with (you saying students don't notice). I was teaching angles, and what I do is I label angles wrong on purpose. And I would keep going on and different kids tell me, that's wrong. They do notice.

John's behavior was not yet in complete synchronization with his idea that students should be monitoring and evaluating the ideas that are presented in the classroom. Because most of the classroom talk was processed through John in the tennis metaphor of discussion, students still were looking for the teacher to evaluate their response. An example of an exchange in this mode gives some insight into what some students were experiencing.

John: And how much is this equal to again?
Jamar: 55 degrees.
John: 55 degrees. Good. Let's try one more. And then go a little more than 90 degrees. So first we have to draw what? Mark?
Mark: A point.
John: A point?
Mark: A ray.

Mark's response of a ray was quickly inserted and almost a reaction to John's intonation about his first answer. This student perceives the teacher as one who evaluates each response. This is in contrast to the desire to have students listening to each other and trying to make sense out of each others' ideas. The tennis image of conversation limits the student's opportunities to develop that type of belief.

This behavior conflicts in some ways to what John described as how he sees discussions taking place in his classroom while solving problems involving pattern recognition.

I'd have someone explain how they did it. I wouldn't just give them the answer or explain my way. I'd take three or four suggestions as to what they thought the answer might be and then have them explain how they got their answer. Then when they realized that it wasn't logical as to
how they were doing it, another person would raise their hand and say that's because and then they would say why they thought it was wrong. If they were still incorrect another person would usually raise their hand and if they didn't raise their hand I wouldn't give them the answer. I'd say now look at this. Can that be right? Is that the right pattern? And then they'd think about it.

John consistently said that the teacher giving the answers was inadequate, and that students should be actively involved in interpreting each others' ideas, but as illustrated above, that mode of conducting discussions did not always carry over into John's performance.

**Category 5: Tasks that Promote Discussion**

John was exposed to several tools to promote discussion in the first quarter. The second quarter gave John the opportunity to integrate some of these tools into his teaching. One such tool is manipulatives. The potential to use manipulatives to teach mathematical concepts opened up new perspectives on how John sees mathematics teaching. When asked how often he used manipulatives in teaching, John responded as often as he could. In several lessons, John used tangrams, geoboards, and figures on a grid to convey concepts he taught during his unit on geometry.

The cooperating teacher did not model the use of manipulatives in his classroom teaching. Working from the understanding of manipulatives he gained in the first quarter, John used manipulatives to solidify a concept that he already introduced. Those tasks that John gave to the students to work on cooperatively seemed to be the most effective. In those cases, John was no longer the center of attention, and students were required to communicate with one another about what was happening. The tangram activity was an example of this. In his journal entry John wrote:

Today was a good day. I planned a lesson on tangrams and also gave a quiz. I had the tangram exercise to create a link between the abstract and
the concrete. On Wednesday I introduced the concept of polygons. The
students were able to make polygons with the tangram shapes and then
classify the shapes they created.

John used the tangrams after having already introduced the concept.

In a lesson that was observed, John used geoboards while presenting the
definitions of several quadrilaterals. In this situation, students were asked to
replicate a given quadrilateral on their geoboards and hold it up to their
chests to illustrate their understanding of what a given quadrilateral looks
like. This task did not engage the students in any exploration nor require
students to communicate understanding to each other. When asked how the
use of the geoboards might impact discussion, John replied that the students
were distracted by having them, because they might want to play with them.
During his lesson he warned the students that the rubber bands were called
gobands, because they were not to be shot like rubber bands. This treatment
of geoboards indicated a limited awareness of ways that manipulatives
improve interstudent communication.

This use of manipulatives, although consistent with John's teaching
behavior throughout the quarter, conflicted with his initial response to how
he would teach a lesson on equivalent fractions. He said that he would
definitely use some sort of manipulative to introduce the concept. When
asked to further explain what he might do, he said that before he would do
the manipulatives, he would stress multiples. This way when manipulatives
were used to show that one-half was equal to other fractions as two-fourths,
four-eighths, and eight-sixteenths, he could easily establish the relationship
between equivalent fractions to multiples.

Another task that influences discussion is engaging the students in
problem solving. A second aspect of problem solving was that this John
usually combined problem solving with small cooperative groups. John reported that his students were not always successful at solving problems, and he tried to get successful students to explain their solutions to less successful other students, encouraging interstudent communication.

Although John did not utilize technology very much during his teaching experiences, he did express the desire to use it. He expressed awareness of the possibility of using the graphing calculator in teaching about translations and reflections. He would have used the Geometry Sketch Pad had it been available. This belief remained consistent with what he had reported after the first quarter.

Journal writing was a task that John expressed interest in during the first quarter, and he capitalized on his opportunity to utilize that tool while teaching the second quarter. This was positively modeled by the cooperating teacher who had the students write descriptions of how to make a peanut butter sandwich and related the order of the steps to the order of operations. John had the students write at the start of the class about their understanding of geometry. He had the students make a list of all the angles in their house for one writing assignment. However, he did not make the connection between discussion and writing, as described in the first quarter.

**Category 6: Teacher Intervention in Problem Solving**

John and his colleagues unilaterally defended the position that the teacher should not intervene by giving the answer, a view unanimously held by their previous teachers, the university professor, and the cooperating teachers. What teachers should do in those situations is not, however, universally agreed on. A common practice, and one that John utilized, was to engage the student in a Socratic dialogue. This involves asking questions that
lead the student to discover their own point of misunderstanding and continuing questioning until students can correct themselves.

A good example of John's approach to this situation during large-class discussions was the following interaction. John was asking the student to define an acute angle.

John: Now the only thing we haven't done is say how much an acute angle is worth in degrees. Daniel?
Daniel: Less than 90?
John: Right.
John: Greater than 180?
Daniel: More than 180. Less than 180? (with a laugh.)
John: Yeah. If it's less than 90 then it's definitely going to be less than 180. Because 180 is more than 90.
Daniel: Oh, less than zero.
John: If it's less than zero.
Daniel: OK. (He giggles.) Less than 90 and greater than 0.
John: Greater than 0. Good. So it's greater than 0.

John pulls Daniel through the response by continually asking questions that allow Daniel to change his response. One reason for John approaching the interaction in this manner is that he does not want to put Daniel down in any way. John's concern for the student's self image is characteristic of John's attitude and behavior toward students. He is very conscious of wanting to affirm students in every interaction that he has. He needs to be cautious, however, to reinforce good thinking and not only good answers.

A final strategy to intervene is to challenge students' thinking. One way John did that is to produce counterexamples to students' ideas. For example, during a discussion about parallelograms, he wanted to have the students identify the conditions necessary for a parallelogram. When students would give insufficient conditions, John would draw figures that satisfied the
conditions given, but were counterexamples of parallelograms. He shared this technique with the other preservice teachers in the seminar.

**Category 7: Orchestrating the Discussion**

John's approach in conducting discussions falls somewhere in the middle of the spectrum between teacher-centered lectures and student-centered discussions. However, he acknowledged in a journal entry midway through the quarter that his instruction was "usually centered around me and what I have to say." This was a very honest and astute observation, shared by most of the people that observed him during these last two quarters. The methods instructor expressed the difficulty for preservice teachers to deviate from this mode of teaching. She stated, "The trouble that obviously occurs to all students is that what they see of the model in the classroom is so much the lecture method that they begin without even thinking about it." The university supervisor stated that John's basic approach to discussions in the classroom were sometimes teacher-centered, and sometimes a mixture of teacher-centered and student-centered. By student-centered, he meant that John tried to tap into the strengths and intuitions of the students. John would challenge the students to recognize that they had the mathematical ability to understand the mathematics being discussed and to respond to the questions being asked.

John's method of orchestrating discussion was basically through questioning. He estimated that 50% of his time was devoted to directing class discussion through questioning. Several themes emerged in analyzing the methods John used during these questioning periods. First, John carried over into the second quarter the practice of wait time. He exhibited extreme patience in interacting with the students, usually giving them ample time to
answer any question that he might have posed. His cooperating teacher had high praise for John concerning this practice. John was able to persevere in questioning a student until either the student answered the question or had given what John considered a good effort to answer the question. At this point John could then praise the student for his efforts. Something that John did not practice under the supervision of the cooperating teacher was wait time after the student answer. This time allows the rest of the students to process the answer and begin to see how it fits with their own thinking.

Second, questions were often interspersed with requests for justification by the students. However, in analyzing the three observations made in the second quarter, the bulk of the questioning was fact oriented. If these discussions were to be classified, they would fall under the category of a recitation. Students were asked questions that often required short responses on the part of the student. Most of the talk in those observations was done by John. One behavior that was detected in the teacher student interactions was that John often repeated and augmented the answer. The following exchange from early in the quarter is typical of this behavior, and demonstrates that behavior.

John: Number 4, I asked you to draw an angle with a vertex at B that also goes through points A and D. So what does it mean to have a vertex at B? Mark?
Mark: Have it in the middle.
John: In the middle. OK. So by the three points, this is going to be B? Is that right?
Mark: If it was at an angle.
John: If it was at an angle. Well, what kind of angle is that?
Mark: A right angle. A straight angle.
John: That’s a straight angle. Good. OK. We also want to go to points A and D. So I have two points left. Does it matter which order I label them in?
Student: No.
John: No it doesn’t. So A and D. So, I’ll draw a different angle.
This exchange took place after a test, and illustrated the behavior of repeating the students' responses. This behavior, which in many cases acted to shut down student listening and participation, is counteracted by John's constant efforts to include all the students in the questioning. Because John frequently called on students, their level of attention was maintained.

**Summary of John's Beliefs and Behaviors after the Second Quarter**

After finishing two quarters of the teacher education program, John developed a sense of confidence in the classroom. His last journal entry attested to a feeling of pride in that he had reached more than one student in his class and felt that he would take that into the high school experience. This sense of dedication towards reaching students was a great asset in John's teaching and was noted by his cooperating teacher and university supervisor. When asked to describe John's approach to discussions, the university supervisor talked more about his enthusiasm and abilities to motivate students than he did about particular behaviors John exhibited. The university supervisor expressed that the one goal he wanted to see in John's method of conducting discussion was that he "was conveying the material and getting it across to the students in such a way where they understood exactly what they were doing." According to the university supervisor, John had accomplished that task.

The image of John that emerged at the end of this quarter, was that of a dedicated, bright teacher who accepted the methods recommended by the Standards. The strength of John's cognitive acceptance of the Standards can be evaluated by examining his behavior in the classroom. As seen in other studies (Ball, 1991), cognitive agreement with a theoretical teaching approach does not always translate into the application of that approach in the
classroom. John exhibits the dissonance between what he says he wants to do and what he actually does. A more complete picture emerges in a summary of the seven categories.

Flow of Ideas. John continued to express the desire to have ideas come from the students. As in the first quarter, this belief was not matched by behavior in the classroom experiences. Concepts were introduced by John before students had the opportunity to explore them on their own. John did, however, provide small-group activities in which students could demonstrate their own understanding of the concepts.

Student/Student and Teacher/Student Interactions. Interstudent interactions were modeled for John in the general methods class and initially by the cooperating teacher in the form of group activities. John incorporated this technique occasionally in his teaching, but the predominant mode of interaction in discussions in John's classes was teacher/student interactions. John's mode of interaction resembled recitation in which the teacher asked a question, the student responded, and John adjusted the next question in order to move toward the predetermined instructional objective. The metaphor of a tennis match described the interactions with the ball going back and forth between John and a student.

Students Justify Their Ideas. John continued to hold the importance of having students justify their answers in class. He felt he modeled this importance for the cooperating teacher to the extent that the cooperating teacher began to ask students for justification in situations where he previously had not.

Acceptance of Ideas. John believed students should feel free to present their own ideas and challenge ideas presented by the teacher. However, the
teacher/student pattern of interaction established in John's discussions did not permit students to perceive anyone except the teacher as the one who evaluates and determines the acceptance of a response.

**Tasks that Promote Discussion.** John believed in integrating the use of manipulatives, problem solving, technology, and student writing into his classroom as recommended by the mathematics methods course. He used manipulatives, but often in a manner that did not promote discussions among the students. Instead, manipulatives were used by students to illustrate concepts, but not to explore concepts through the manipulative or justify their understanding of a concept to the teacher or to other students.

John used cooperative problem solving, having successful students explain their solutions to less successful students. John had students write at the beginning of geometry classes about their understanding of geometry, and expressed the desire to utilize technology if it had been available.

**Teacher Intervention in Problem Solving.** John held the belief of not giving students answers when they got stuck on a problem. This was reinforced by all the educators with whom he worked during the quarter. John developed the technique of entering into Socratic questioning to help the student discover their own point of misunderstanding, allowing the student to correct themselves. John also used counterexamples to challenge students to reconsider their ideas.

**Orchestrating the Discussion.** During the first quarter, John had moved away from believing he would be the center of discussions to allowing students to do more of the talking. John continued to work on his wait time, but did not continue to monitor his tendency to repeat students' responses. In addition, John sometimes augmented students' one-work responses with addition
information about the concept. These behaviors went undetected by the university supervisor and the cooperating teacher. This produced a discussion pattern that was teacher-centered, in which John admitted he did most of the talking, usually in the form of questioning. John's attentive questioning did maintain the attention of the students toward John, but with little attention toward one another.

In summary, John came into the program expecting to get up in front of the classroom, provide the students with the essential knowledge they needed, and test to see if that knowledge was mastered. Through methods instruction and field experiences, he encountered new ideas on how to conduct classroom discussions that he attempted to put into practice. He incorporated small group instruction into his lessons, he developed the technique of wait time, he worked at using questions to incorporate all the students into the lessons, he asked students to justify their thinking, he understood the use of non-examples in helping students understand potential misconceptions they exhibit, and he used manipulatives to help convey mathematical concepts. Along with this growth, some behavior patterns that conflicted with the approach recommended by the Standards were identified. John often repeated the answers of his students during classroom discussions, potentially shutting down interstudent communication. The verbal interactions were almost exclusively done through the teacher, creating classroom discussions that resembled the image of a tennis match between the teachers and the students. Although this practice was identified by the cooperating teacher during the first quarter, it was not addressed in the second quarter. John used manipulatives during instruction, but not always in a way that allowed students to explore concepts
on their own before mathematical language is introduced. John used cooperative groups infrequently during the quarter, usually during his own teacher-created activities.

These results indicate that John made progress towards developing teaching techniques in discussion that reflected the Standards. However, behaviors identified in the first quarter that needed correcting went unaddressed, and other behaviors that could negatively affect discussions went undetected. John expressed disappointment in that little corrective feedback was given by the cooperating teacher or the university supervisor. Considering the openness that John exhibited towards changing his teaching behaviors, more detailed feedback to John would have been in order.
CHAPTER VI
THE CASE OF REBEKAH

Background.
Rebekah entered the mathematics education program as a 20-year-old junior with a strong and diverse academic background. Her secondary school education spanned three schools, all within the same school district. She attended a middle school for grades 6-7, a junior high school for grades 8-9, and a high school for grades 9-12. She had a 3.98 index as a high school student and took calculus at a local university during her senior year. In college she had an overall G.P.A. of 3.4 and a mathematics G.P.A. of 3.5. Rebekah was the only student studied who was married.

She frequently referred to her experiences during her secondary school years as being out of the mainstream of events, both academically and socially. Despite a natural interest in helping people learn mathematics, becoming a teacher was not her original intent when she enrolled in college. She planned to go into engineering in order to "make lots of money," but that priority changed when she arrived on campus. As the desire to do something meaningful with her life grew, Rebekah focused her attention on improving mathematics instruction, an area she felt was lacking.
Several factors influenced that decision. First, the more Rebekah examined the mathematics instruction she was receiving, the more she felt how "bad" it was. Of all the candidates examined in the study, Rebekah expressed the most dissatisfaction with the present system with respect to the way mathematics was taught to her. She expressed on several occasions that her success in mathematics depended little on the competence of the teachers, but rather on her ability to make sense of the subject. She felt that left alone with the mathematics textbook, she probably could have achieved the same level of competency. Second, she was deeply moved by an experience involving her father, whom Rebekah tutored in mathematics as he returned to school to study for his associate degree. She said that as a result of "teaching" her father to do fractions, "we bonded the most when we sat down and I taught him math."

Rebekah considered herself somewhat of an outcast when referring to her relationships with her peers while in school. She was isolated socially, because she was dating her future husband early in her secondary school experience. She felt much the same with respect to her classroom experiences. She characterized herself in the following terms while describing her experiences working in groups in high school:

I didn't fit in with brainy kids and normal kids ..... I was the one who did all the work in class and who didn't work in groups because I didn't fit with the class. I was kind of a shy kid, and I wondered how many teachers would have adjusted to a kid like me because I was kind of a weird one.

She was content to "hide away" in class, sometimes sharing her insight, sometimes not, sometimes sleeping through class. Rebekah was an intelligent student who found mathematics boring, and who decided that she would like to do something to make a difference in a mathematics classroom.
Incoming Experiences and Beliefs Concerning the Secondary School Mathematics Classroom.

Rebekah viewed her experiences in the secondary school mathematics classroom as consistently mediocre. Her teachers expressed little interest in making mathematics a topic students could understand. Although this attitude by her teachers produced strong feelings that something was wrong in mathematics education and strong beliefs that what she had experienced was inadequate, they did not produce strong beliefs about what should be done in order to make the mathematics class more interesting and effective. Her experiences and beliefs, as recorded in the seven categories, help present the picture of Rebekah's beliefs coming into the mathematics education program.

Category 1: Flow of Ideas.

The picture of the kind of classroom Rebekah experienced during her secondary school years can almost be summed up in her description of the role her teachers took; "the teacher lectures and the students listen and learn." This is the image of passive students who soak up all the gems of wisdom the teachers offer. When asked about different scenarios for discussion that took place in her classes, Rebekah responded:

Honestly, the only discussions I ever remember having in our mathematics classes would basically be the lecture, the teacher lecturing. We would put problems on the board, but that would be as active as we would get in learning, in doing the whole process. We'd put a bunch of problems on the board and then sit down and discuss them. But it wasn't a discussion of why we would do this, it was either right or wrong, and this is how you do it.

In this type of classroom, the flow of ideas was squelched by the teacher's need to have the right answer as the focal point of the discussions.
In contrast to this, Rebekah expressed several hopes she had for the mathematics classes she conducts. First, she would have a lot of ideas coming from the students. She wanted the students to see that there is more than one way to do a mathematics problem. Second, she felt it was important for students to see that these seemingly different ideas are in fact the same, that they imply one another. Third, she wanted students to feel that their opinions were valued. She expressed the desire to be open to students ideas in the mathematics class.

Much of this was a reaction to Rebekah's own teachers' behavior during discussions. When she offered a solution, the teacher would acknowledge it for her, but would not extend the opportunity to Rebekah to share her ideas with the class. This behavior indicated that the student's idea was not important to the body of knowledge being transmitted in the class.

**Category 2: Student/Student and Teacher/Student Interactions.**

The interactions that took place in Rebekah's classes are not difficult to imagine based on how her teachers responded to the introduction of ideas by the students. Students hardly ever worked in groups to explore problems on their own. Rebekah couldn't remember that type of experience, except in Chemistry or English classes. In the full-class setting, the predominant mode of interaction between the teacher and the students was going over problems at the blackboard. When asked to describe her teachers' interactions with the students in her class, Rebekah classified them as:

More keeping you on the right track. [Saying what her teachers might have said] 'Well, you're doing this wrong and this is how you do it right.' Then you go on.
The picture of the discussion is that of recitation in which students gave responses, and the teacher tried to steer the students in the "right" direction; i.e. the method that the teacher wanted the students to master.

Rebekah expressed frustration with this type of discussion. She would have preferred more open discussions about what people were thinking and why. When solving problems, she said that she:

would be inclined to have the students come to the board and explain [their answer], and try to go through the whole problem on the board to show the rest of the class what their line of thinking was.

During this time, the rest of the class would ask questions, throwing in their own suggestions, with Rebekah being cautious to not allow students to just give the right answer without justification.

Rebekah was not hesitant to say that she would use small-group instruction in her classes and that children learn well in small groups. However, due to her experiences in which she was often the one who did the work in small-group situations, she was cautious about the implementation of small groups in instruction, and saw her role as the person to go around to the groups to make sure that they were remaining on task.

**Category 3: Students Justify Their Ideas.**

Rebekah's teachers seemed more concerned with correct answers than with student reasoning. The flow of ideas and types of interactions that took place in her mathematics classes indicates that, despite Rebekah's response that her teachers asked their students to justify their answers daily, the justification was directed toward verifying the accepted method proposed by the teacher. Rarely, according to Rebekah, did the teacher deviate from that path.
Rebekah expressed frustration with her teachers who stressed the correct answer alone. When describing what she would do in discussion, she said:

Hopefully, my discussion would be going in the direction to encourage students to not only think of the correct answer, but maybe two or three different ways... So I will encourage [the students] to look at more than one way and not be so concerned with the right answer but getting the right process...We are putting so much emphasis on the right answer, when I think it should be put to the right process.

Rebekah felt strongly about not just giving right answers, either by the teacher to the students or by the students to one another. She would find out students' thinking in order to find out where they went wrong. Similarly, students would be encouraged by Rebekah to not just give answers to fellow students, but have the students explain their thinking to one another. This would all be directed toward the goal of having students understand what they were doing in order to apply it to more difficult situations.

**Category 4: Acceptance of Ideas.**

If students were being directed toward a right answer, there would be little room for the expression of their ideas in Rebekah's experience. When asked what her teachers would do when students gave answers during discussion, the response was clear. "Right" answers were praised in a matter-of-fact fashion, while "wrong" answers were corrected, yet not in a demeaning way. When students offered alternative solutions to problems, the teachers redirected them toward the recommended methods of solution.

Rebekah was not in favor of this approach. When asked what she would do during discussion, she replied:

I would let them go more on their own, let them discuss more possibilities. From my experience, we would have one right answer. Somebody else would be like well, basically what about this? [The teacher] would be like, "Yeah, that's right, too," but nobody would ever explain it. The teacher would acknowledge it was the correct answer, but
would not explain the whole process....I think that allowing more people to discuss more ideas would allow students to understand that there's a broader possibility. I was taught if you get the one right answer you're good. If you get an alternate answer, you're OK, but this is the one right answer.

The picture of Rebekah's mathematics classes is that of the typical rule-driven, procedure-oriented mathematics classroom, where the goal was the answer. The teacher had the answers, and the students adjusted their thinking to conform to those answers, a principle to which Rebekah reacted negatively.

**Category 5: Tasks That Promote Discussion.**

The mathematics classroom that Rebekah experienced seemed to have set routines. Class discussion focused on problems that were put up on the board for the students to do. The task set by the teacher was to get the right answer. Alternatives to that goal were tolerated, but not rewarded. Problems were more like the word problem in Scenario II promoting a procedural approach to problem solving. Questions similar to those in Scenario I, in which students collaborated to explore the different possible solutions, were nonexistent in Rebekah's mathematics classes until college.

At the time of the first interview, Rebekah was already thinking about alternatives to this type of task setting. Concerned about the understanding that students develop, she brought up the possibility of manipulatives in the classroom and alternative tasks that deviate from the students sitting in rows, going over problems at the board. The concept of manipulative use was one that Rebekah heard in her first week in the methods class, therefore not a preconception with which she entered the program. However, she was able to relate their use to a term paper she did during her freshman year on creative drama. The paper contained notions such as having students use
their own bodies to form circles on the floor. Rebekah was enthusiastic about this instructional alternative, demonstrating her desire to change her classroom from the ones that she experienced.

**Category 6: Teacher Intervention in Problem Solving.**

When students in Rebekah's classes got stuck in their thinking or hit obstacles in the mathematics process, her teachers tended to help the students by asking simpler questions to direct the students to the right track. The objective was to "get you going again."

This was the one area in which Rebekah did follow what her teachers would do. Although she did not know the exact method, Rebekah did refer to the Socratic method of dialogue as the method she would use to help students who could not answer a particular problem. When asked about what she would do if a student got stuck on a problem she replied:

I can't think of his name, some Greek philosopher, asking them questions. Asking them simple questions. For the life of me I can't think of his name. Socrates, I think.. The process of just asking the simpler questions, and getting them thinking about these simpler questions then saying, 'OK, now apply all this knowledge that you have. You know a lot, now put it to the big problem. You really know the answer because you know all the little answers.' I think that's the way to go, you don't give them "the" answer. You definitely don't want to do that. You try to ask intelligent simple questions so that way they can find their own path of what they think is right, but yet it's still their own ideas.

Rebekah demonstrated early in the semester that she expected free thinking from her students. She was not going to be the dispenser of correct answers, but believed that students understood more than they thought they did, and that the right questions would draw that out of them. She believed in helping students learn to apply the understanding they already had.
Despite that philosophy for her teaching, Rebekah's tutoring experiences revealed that she was not always able to apply that concept while working with students in a tutor/student relationship. She acknowledged this herself in describing her tutoring experiences:

I don't know if I was a good teacher as a tutor just because I did a lot of ...this is what you want to do, this is what you want to accomplish, so here, I'll teach you this. I got the ideas across, and people passed, so I guess that was the goal and I accomplished that.

Rebekah illustrated that circumstances often affect how teachers' beliefs are translated into behavior, and that the translation is not always positively correlated.

**Category 7: Orchestrating the Discussion.**

Lecturing was the standard fare for discussions in Rebekah's mathematics classes. When asked to describe different possible discussion scenarios that she had experienced, lecturing was the first one she came up with, followed by the discussions that took place when students put problems up on the board. There was an almost total absence of variation from this scenario. Collaborative problem solving was nonexistent. Questioning strategies almost exclusively centered around the teacher asking questions that led the students through the problem.

Rebekah did not favor a lecture approach. She was open to using collaborative problem solving and described herself as a facilitator who helped keep students involved on the task as she went around the classroom, while not becoming part of any group. Her questioning strategies would tend to reflect the Socratic method in directing student discussions. Questions were her avenue to allow students to see what they actually knew.
Rebekah expressed confidence in her ability to teach at both the junior high and senior high school levels. She had little difficulty picturing herself up in front of a group of students, either the full class or leading discussions with small groups. She said:

I'd be comfortable anywhere, either in front of the whole class or in groups. Maybe I feel that I can talk more. I don't know. It's hard to explain.

This confidence is in contrast to her expressed shyness, and is seemingly a result of her own ability to talk about and do mathematics.

Summary of Rebekah's Preconceptions

Rebekah brought to the mathematics education program several ideas about the way mathematics class discussions take place based on her reactions to her own learning experiences in which teachers routinely stressed right answers more than thinking or understanding. Rebekah anticipated that the mathematics education would help her establish teaching techniques to address this issue. Her preconceptions in the established categories are summarized below.

Flow of Ideas. Despite having learned mathematics in which ideas were introduced by teachers lecturing, Rebekah envisioned a classroom where the ideas initiated by the students are valued and used to demonstrate the connections between ideas.

Student/Student and Teacher/Student Interactions. Rebekah preferred to have students interacting more with each other in cooperative settings and not simply lead students to the desired response. Rebekah expected the students in her classes to demonstrate their thinking to the rest of the class.
Students Justify Their Ideas. Rebekah believed that students needed to justify their answers and she would have students explain their thinking to one another in class.

Acceptance of Ideas. Rebekah expressed the belief that ideas would be accepted on the basis of whether or not they could be justified by the students.

Tasks to Promote Discussion. Rebekah was concerned about the set routines in which the goal was to find the "right" answer. Rebekah anticipated learning new ideas in the methods class and was already thinking about using manipulatives in class.

Teacher Intervention in Problem Solving. Rebekah advocated the Socratic Method of leading students through a problem through a series of questions that help the students understand the extent of their own knowledge, despite sharing about tutoring experiences in which she basically showed the students what to do.

Orchestrating the Discussions. Rebekah's approach to orchestrating discussions was not to lecture, but to engage the students in questioning to see what they knew. She felt comfortable about the prospect of being in front of a class and leading discussions based on her ability to talk about and do mathematics.

Rebekah's preconceptions of what takes place in mathematics classroom discussions was clearly affected by her secondary school experiences. She appears to be a student who learned despite the system, and one who was reflective enough to formulate the opinion that the system was not working. Her decision to go into mathematics education was, to a large extent, motivated by that dissatisfaction. Interestingly, she acknowledged that teaching in a way that was similar to her own teachers would be comfortable
for her, but that she was wary of that comfort. After rating her comfort level at teaching like her teachers as a 9 out of 10, she said:

I don't know if that's good. I don't know if I want to be that comfortable. It's not far from my experience, so I would be comfortable, but I don't know if that's good. I think sometimes I should be uncomfortable for the students sake.

Rebekah was ready to move out of her comfort zone and expected the mathematics education program to provide the means by which she could develop her teaching abilities.

In summary, Rebekah brought to the program several ideas about the way mathematics class discussions took place. She wanted the focus of mathematics discussions to be more than a quest for right answers delivered in a lecture mode. She would encourage independent student thinking and student sharing of that line of thinking with the rest of the class. Rebekah expected the mathematics methods course and field experiences to provide instruction to develop her preconceived ideas about conducting discussions. She was confident in her ability to conduct discussion in front of the classroom, and felt she possessed several qualities of a good teacher: enthusiasm, organization, openness to students' ideas, and the ability to express herself. Rebekah wanted to include more students in the discussion. She would accomplish this by asking questions and creating an atmosphere in which students did not have to be afraid of mathematics, a phenomenon that she felt causes 90% of the problems people have with mathematics.

Perceptions of Her Role in Discussion After Participation in the Mathematics Methods Course and Related Field Experience,

Rebekah came into the mathematics education program with the expectation that learning how to be a teacher would be a systematic process. When she first entered, she said "I pictured [teaching] to be more of a
structured thing; that you did it right or you did it wrong, and I pictured it to be a much more critical, scientific, this is right, this is wrong teaching way."

This characteristic was picked up on by the methods instructor who perceived Rebekah as someone "who likes things structured," and "would want things under her control." Rebekah continued to manifest this perception during her field experience. The first lesson she presented was observed by the cooperating teacher and the methods course instructor. Rebekah thought she was going to sit down after the lesson and the observers would tell her all the things she did right or wrong. She even referred to this as if she were going to be "grilled by an army." Although comments were made, they were not prescriptive in nature, a fact Rebekah appreciated by the end of the quarter.

For her field experience, Rebekah was placed in a fifth-grade classroom in a local elementary school in the same district as the other participants, with a cooperating teacher who had considerable experience in education. The teacher had been in education for 28 years at practically all levels. She taught high school English for 4 years, was a lecturer at the university level for 11 years, taught English for 5 years at the junior high school level, and had been in the elementary school for 8 years. Both Rebekah and the university supervisor noted the superior ability of the cooperating teacher to conduct discussions, motivating students to be active participants in the discussion segments of the class.

Rebekah, however, noted that the cooperating teacher's expertise was lost while teaching mathematics, because of the teacher's procedural approach to learning mathematics. In several journal entries and during the second interview, Rebekah noted that she felt the cooperating teacher stressed the
learning of mathematical algorithms, without ensuring that the students understood the concepts underlying the procedures.

The field-experience classroom afforded Rebekah ample opportunity to be in charge of the class, but not always in conjunction with mathematics instruction. She was responsible for leading the students in a discussion of a weekly news show called Newsdepth and accompanied the students to a computer laboratory where they worked on word processing skills. She only taught actual mathematics lessons on two occasions. One lesson on averaging and another on the use of the memory key on the calculator. In addition, Rebekah presented to the class her bulletin board that connected a visual feature of a mathematical term with its meaning. For example the word exponent was written as, exponent. On each of these occasions the cooperating teacher wrote notes with observations of the lessons and suggestions for future lessons. Whenever the university supervisor or methods class instructor were present, they also commented on the lesson.

Rebekah was an active participant in the methods class. Despite a certain amount of uneasiness about getting her teaching right, Rebekah was not shy about sharing her ideas in the methods class. She looked to that portion of the program to provide the guidance she was seeking. One aspect of the course she appreciated was the information she received by reading articles in professional journals such as the Mathematics Teacher and the Arithmetic Teacher. This requirement of the methods class appealed to Rebekah's desire for knowledge about teaching methods.

Preconceptions Rebekah had about teaching were challenged by several factors during the Autumn Quarter. First, she was exposed to the new ideas in the methods class. Second, she was asked to observe and reflect on the
practices and expertise exhibited by her cooperating teacher. Third, she was confronted by actual contact with fifth-grade students. Refinements in Rebekah's perceptions of the teacher's role in discussion took place over the course of the quarter. The following sections chronicle that process in each of the seven categories.

**Category 1: Flow of Ideas.**

Rebekah had already expressed beliefs that ideas should come from the students and that the teacher should not dominate a discussion with a lecture about what the students needed to know. The methods course and field experiences, such as reading the accepted literature, attending methods classes, hearing how other students thought about teaching, and teaching her own lessons, forced Rebekah to either assimilate or accommodate those experiences into her beliefs system.

The most significant impact on Rebekah's beliefs about receiving students' ideas in classroom discussion came from just experiencing children as individual people who have hosts of ideas, some right on target for a topic and others that stray far from the topic. Despite feeling like she always liked working with children, she was surprised to learn that, with respect to the learning experience, she thought of them in an almost mechanical fashion. When relating her revelation about this, Rebekah said:

> I've never thought of them as robots except when they are in the classroom, when they're supposed to be perfectly understanding everything.

For example, in one of her first lessons, she had noticed that the students' concept of average was not clear, and she asked to do a lesson on averages. Rebekah formulated a detailed lesson plan in which she would use unifix cubes to teach the concept. Her first question was to ask the students
what the word AVERAGE meant. Her lesson plan had been to receive any response without rejection of the students' ideas and then lead them toward the concept by having the students find the average height of a group of unifix cubes of unequal lengths. However, the students took off in the direction of batting average in baseball, temporarily disrupting Rebekah's plans. Both observers of the lesson, the cooperating teacher and the methods instructor, noted that Rebekah had a difficult time redirecting the focus of the lesson back toward the intended concept. Rebekah wrote in her journal that she felt like running out of the room after this "fairly disastrous beginning."

The lesson continued to not run according to plan when the students did not do what Rebekah expected them to do with the manipulatives. The original cubes were given out in six strands, and Rebekah wanted the average length of the six strands. Soon the students had broken up the strands and some groups were working with 12 strands. What was at first very disturbing turned out to be a good learning experience for Rebekah. After reflecting on this event and the comments made by the cooperating teacher and the methods instructor, Rebekah realized the importance of allowing students to initiate and explore ideas on their own. In recounting how the use of the unifix cubes had changed the nature of the discussion in the lesson, Rebekah said:

It was funny, because the kids sometimes headed off in different directions, and so one group was trying to figure out how many even columns they could come up with, instead of leveling off as close as possible in six columns. They came up with, well I can have 12 even columns or I can have this many even columns. And so that led a discussion of, OK, how is that not averaging. It kind of clarified not only what averaging was, which I think many times we teach what it is. But, then these kids don't have any concept of what it isn't. And I think that is where some of the fallacies I know came in that I saw in the class is the kids learn what something is, but they didn't learn what it is not. And so
that discussion really, the manipulatives basically, if they weren't there we would never have discussed even columns. So that kind of clarified, this isn't averaging, but it's something, but it's not definitely what we want. So that was one good thing.

Rebekah learned that allowing students to explore their own ideas and discussing what they find can enrich the students' conceptual understanding.

Rebekah felt that her classroom situation provided her the freedom to explore the students' ideas more, because she was not constrained by a portion of the curriculum the students needed to master. She noted this contrast between her own teaching experience and the teacher's perceived quest for the "right" answer in her own learning experience. This enabled her to have the goal of saying to students, "here's a problem, let's look at the different ways we can solve it."

A second aspect of Rebekah's view of how ideas are introduced in the classroom evolved over the course of the quarter. This occurred as a result of Rebekah's efforts to understand conflicting comments made in the methods course about the teacher's role in discussion. Early in the quarter, Rebekah thought that the methods instructor was saying that students should lead the discussion. Whereas, later in the quarter, she heard the instructor say that the teacher really needed to be there to keep [the discussion] from going astray. Early in the quarter, when Rebekah tried to apply the recommended teaching method with the students leading the discussion, she reported the following results:

And when I would try [letting the students lead the discussion] I would find that they would start talking about anything. And so I felt that I had to take a little bit more control. But then toward the end of the quarter [the methods instructor] said something. We had a day we were discussing the teacher's role in leading discussion, and she made the point that you really had to be there to keep it from going astray. I remember thinking these two lessons, one from the beginning and one
from the very end conflicted. And so I didn't buy into the very beginning one, and then in the end I may have misunderstood to what degree she meant in the beginning. I remember thinking, that's a great idea. Sure, we'll let these kids talk on their own and they'll say intelligent things. Then I tried it and they didn't say anything very intelligent. They started out throwing out basic guesses of topics they could talk about.

This experience prompted Rebekah to reevaluate her understanding of what the methods instructor was saying. She retaught the lesson the following week, in the presence of the cooperating teacher, who had been absent the week before. Rebekah recounted the following results for the second lesson:

It ended up that the [first] lesson went so bad that they hadn't learned anything. It was on a Friday, so the next week on Thursday, we did it again. I still used the questioning what button you think we would use, but I went more into a detailed discussion of what each of the buttons did. More of a conversation and let them take over more of an each individual button function conversation. So I let them explore smaller topics so they couldn't go off too far. And I kind of limited their discussions to smaller topics. And I think as you get better as a teacher, you can broaden those topics, but I felt that to keep it small was the best idea to begin with, because they really did get off onto some wild tangents.

This reversal of outcomes occurred because Rebekah refined her ideas about what leading a discussion involving the students meant. She accepted the newer version of the teacher's role in discussion in which the teacher does not allow students to discuss their ideas without being guided by the teacher. Rebekah wanted to begin with more teacher direction, and then broaden the topics as students mature.

The third impact on Rebekah's perceptions of how the teacher acknowledged students' ideas was from the inferences Rebekah made about the teaching modeled by the methods instructor. The methods instructor often let the students direct discussions about the articles that they had been reading. She would ask open-ended questions to elicit students' ideas,
reinforcing the teaching concept that it was important to respect the students' ideas. While effective for the college level, Rebekah felt that letting students lead the discussion would not work for the fifth grade. She did, however, believe that respecting students' ideas and asking open-ended questions promoted student participation in discussion.

**Category 2: Student/Student and Teacher/Student Interaction.**

The principal form of teacher/student interaction Rebekah experienced during the Autumn Quarter was that of teacher questioning. Because this was already how Rebekah perceived herself acting when conducting discussions, her learning experiences reinforced this behavior and belief. The methods instructor emphasized questioning throughout the quarter, especially the "why" question. When critiquing Rebekah's lesson on average, the methods instructor observed the variability of Rebekah's questioning skills. She complimented Rebekah on her ability to think on her feet, and to ask follow-up, leading, and "why" questions.

Despite the goal of involving students in group discussion using provocative questions, Rebekah noted that she and her professors did not always practice what they recommended. A typical type of question the inservice teachers alluded to was the "read my mind" question. When leading a discussion and wanting to "keep the students on track," the professor will often ask a "fill in the blank" question. The methods instructor admitted to doing this occasionally, and the inservice teachers mentioned it during the interviews. Of interest, however, is Rebekah's analysis of this phenomenon. She said:

It's one of those things that you don't know what else to ask, but you want to ask something. So you ask one of these what am I thinking questions.
Rebekah was saying if you do not want to lecture, but still want to transmit material, just ask a "read my mind" question. It accomplishes the same result, because if they cannot do it, then you share the answer. If the students do know the answer, you accomplished the task of getting the material into the discussion.

Rebekah found that questioning was not easy. She expressed the need to develop her ability to properly gauge the students level of understanding. Rebekah was aware of the need to develop the teacher's behavior of matching the students' grade level with the level of the question. However, since she felt fifth-graders were not able to hold discussions on their own, question posing was the method by which student involvement was initiated. Rebekah estimated that more than half the time in classroom discussion was spent on her questioning the students.

I would say at least half [the time teaching] I was posing questions and they were answering and building upon things. And with some work I would like to cut back more toward them more asking and discussing among themselves. I think also with fifth-graders, I don't mean to criticize their ability, but I found they had a hard time discussing things. I don't know if that's their grade level or their age, but they would either. They had a hard time discussing among themselves, without being asked very specific questions.

Her ideal would be to have the students interact more among themselves, but Rebekah was not able to envision that at this stage of her development.

A second aspect of Rebekah's views about participant interaction in discussions dealt with the use of small groups. The methods class used small groups extensively during the quarter. Despite the fact that the cooperating teacher rarely used small groups for her mathematics instruction, Rebekah incorporated small groups into her first lesson on averages. She learned that the makeup of the groups played an important part in their effectiveness and
the types of interactions that would take place. Rebekah accepted the cooperating teacher's suggestion that the teacher should place students into their small groups unless there was a specific reason not to do so.

**Category 3: Students Justify Their Ideas.**

The emphasis placed by the methods instructor on having students justify their answers reinforced Rebekah's preconceptions. With that fact, complemented by the notion that questioning was important in discussion, particularly the "why" question, Rebekah was able to assimilate this approach into her own beliefs system. While teaching the full class, teaching small groups, or tutoring individual students, she consistently made note of wanting the students to understand why they do what they do.

Rebekah felt that reasoning was an important part of discussion and should be exploited during problem solving. When asked how problem solving affected discussion, Rebekah replied:

> I think the logic problems give them the reasoning, the skill which is really important to discussions, because in discussions you want to build on things, you don't want to just come out and guess, where you have no foundation. And that way when you ask them, OK, where did you get that answer, they'll have the reasoning skills to tell you where the answer came from.

In this respect, Rebekah's beliefs reflected the *Standards* emphasis on mathematics as reasoning.

In addition to her teaching experiences, having students justify their ideas was modeled by the methods instructor had an impact on Rebekah's perceptions about having students justify their answers. In contrast, although an effective teacher in conducting discussions, the cooperating teacher did not emphasize having the students justify their answers in mathematics lessons.
Rebekah remarked that students did not make the connection between multiplication and division because the cooperating teacher did not require the students to tell from where they got their answers. She recorded in her journal:

It's kind of funny, because we did division. We just started doing division about midway through my time there, and one thing the cooperating teacher had them do was check them, you know, you multiply and add the remainder. And the kids kept forgetting this. They kept forgetting how to check it. And I think it was because they were just told, you multiply this times this and add this and never connected that this times this plus the remainder is what division is. You know, your remainder is something left over. Your division is actually a multiplication problem. And so I think reasoning skills would have really helped them make that connection, and then they wouldn't forget how to check their division problems, because it would be so obvious to them.

The methods instructor, however, consistently asked the students to justify their ideas during the discussions that took place in the methods class.

Evidence of the extent of Rebekah's belief in the importance of having students justify their responses was recorded in a discussion in the methods class near the end of the quarter. While discussing how the preservice teachers responded to students who called out answers, Rebekah said that she would call on other students to have them explain why they made their response, and then praise those persons. In this way she felt that she glorified students who were able to explain their answer and not students who shouted out the right answer.

**Category 4: Acceptance of Ideas.**

Two of Rebekah's preconceptions influence how ideas will be accepted in Rebekah's class. First, Rebekah was sensitive to having the students' ideas respected. In her first lesson plan, she noted that all the students ideas would
be accepted. Second, she wants ideas to be accepted or rejected on the basis of whether or not they can be justified.

The idea of letting the student be an integral part of determining what ideas are acceptable or not was modeled by the methods instructor. Several of the methods classes had the students leading the discussions and commenting on what teaching ideas were reasonable or not. This was not, however, reinforced by the cooperating teacher. The cooperating teacher's view of a rule-driven mathematics curriculum was illustrated by her response to what she would do if a student came up with an idea that did not fit in with the perceived method. She said that if the student were to add 1/2 and 2/3 to obtain 3/5, she would just tell the student that "when they are adding, they don't do that." Rebekah saw that this approach did not allow students to develop their understanding of concepts, and opted to follow a method that incorporated students ideas into the class discussions.

However, there was still confusion as to how to accomplish the curriculum and still empower the students to accept or reject ideas based on the reasonableness of the idea and not the teacher's approval of the idea. In the sequel to the calculator lesson, a lesson in which Rebekah allowed the students to generate the function for the memory key, Rebekah was determined to assert her authority in the lesson. She wrote in her journal:

In some of my past lessons the children have been able to convince me that doing it their way would be a good idea. I have always regretted these actions and this time effectively avoided a "con job" by bluntly stating that we were going to do it my way.

Maintaining authority is a major concern for novice teachers, as evidenced here by Rebekah's comments.
Category 5: Tasks That Promote Discussion.

Like the other students in the study, Rebekah did not have prior experiences with the kind of mathematical tasks suggested by the Standards. The introduction in the methods class to the possibility of choosing tasks other than the typical mathematics textbook tasks had a great impact on Rebekah. Her classroom behavior, comments in her journal, observations by those who supervised her field experience, and responses to interview questions indicated that methods instruction about alternative tasks and the tools involved with those tasks had a great impact on Rebekah's thoughts about teaching. She had already expressed an openness to learning new ways to teach mathematics, and the professed "brainwashing" by the methods instructor with respect to calculators and manipulative materials provided the new approaches needed to fill that void.

Rebekah reported that the most significant influence on the way she perceived teaching was the introduction to the use of calculators and computers in the mathematics classroom. Rebekah described her feelings after the methods class instruction:

I always thought it was a little cheating tool I guess. A little thing you could go home and do your homework on at home, and if you were a little bit smarter than everybody else, you could cheat with it, and not get caught, because you could put down all the lines. Just use your calculator to punch up all the lines. So I really did view it as something that you didn't learn with, you used after you learned everything. I think from my methods class, that's been the most profound thing that I've seen. The importance and the uses you can have with calculators and computers.

Rebekah revealed two profound preconceptions that she brought into the education program about her thinking related to calculators in the classroom that changed as a result of her participation in the program. First, she echoed the thoughts of many parents and teachers in thinking that the calculator was
a cheating tool. Second, she believed that calculators were to be used after instruction, not as a tool for instruction.

The implementation of the use of technology for instruction was not without conflicts. Rebekah noted that students would often choose the lowest level for computer mathematics games in order to make the game simple. Prior to the methods class, she explained that she would not have been concerned with that, whereas after instruction, she wanted the students to attempt a game appropriate to their grade level so that the game would challenge their understanding of the concepts involved in the game.

Similarly, in her very first lesson, Rebekah made up an activity in which the students solved a puzzle by inserting the correct operations between a series of numbers in order to obtain a given number solution. The students balked at the difficulty of the puzzle at first, but Rebekah persisted with the activity until the students became involved in the game and expressed joy at solving the puzzle. Rebekah came to see that technology affected concept development, because it provided the students with an alternative method of picturing the concept, giving the students another way to share their understanding of a concept.

The second task choice to make an impact on Rebekah was the use of manipulatives. Rebekah accepted their use from early on in the methods course instruction. Despite the fact that the cooperating teacher did not often model manipulatives use in teaching mathematical concepts, and that Rebekah had not been introduced to their use before, she attempted to use them in her lessons. In her lesson on averaging, she used unifix cubes as a manipulative that the students could use to illustrate the concept of average.
She felt that the lesson went very well and was "gung ho" on using them in the future.

One aspect that Rebekah had not completely confronted was the distinction between using manipulatives to interest the students in the activity and using manipulatives to clarify a concept. After Rebekah explained that it took her several times to understand how the manipulatives in an article she read demonstrated the flip and multiply algorithm for division with fractions, the methods instructor asked whether the activity had become easier or had the concept become clearer. The distinction between the two is very important to the ultimate use of manipulatives. Rebekah demonstrated some understanding of this distinction in her lesson on averages. She noted in her lesson plans that she would have to ask between what two whole numbers the average would be, because the unifix cubes could not represent fractions.

A third task emphasized in the methods class was problem solving. Rebekah saw the connection between problem-solving tasks and their impact on discussion. When discussing the problem of getting students to listen to each other, Rebekah felt that one way was to assign more problem solving, forcing the students to rely on the knowledge of the other students in the group and not on the teacher. Possible contributors to this view were a teaching experience that occurred after the Newsdepth television program in which students were asked to find an area of 300 square feet, and the many group problem-solving experiences Rebekah had in the methods class.

Rebekah indicated her belief in the importance of problem solving when discussing the math track system, a form of mastery learning, the cooperating teacher instituted the last few weeks of her experience. Rebekah felt the
program put more emphasis on the answer and made the error of not putting the computations into a problem-solving context. Rebekah's lessons emphasized problem solving and she had originally intended to do a bulletin board with a problem of the week. However, Rebekah expressed how difficult it was to identify problems that were at the students' ability level and with which they had no prior experience.

One other task to which Rebekah was introduced was student writing. Although Rebekah incorporated writing into student assessment in the averaging lesson and the measurement lesson she prepared with a group in the methods class, this task did not seem to have significant impact on Rebekah during the first quarter of instruction.

**Category 6: Teacher Intervention in Problem Solving**

At this stage of her development, the data gathered did not reveal how Rebekah would act to intervene in a student's problem solving process. However, based on comments from her journal, Rebekah would always stress the "why's" involved in learning a concept. This would be true whether it was in one-on-one tutoring situations or in the full class situations. Rebekah believed that students would be less likely to make mistakes in applying algorithms if they understood the reason why they work.

A second aspect of her approach is to get students involved in some way. Rebekah would do this by engaging students in a series of questions or by calling them up to the board to explain an answer. She would not just skip over them and go on to other students, even if they were not able to express their answer verbally.
Category 7: Orchestrating the Discussion.

Although the methods class instructor heightened the students' awareness that the dominant figure in classroom discussion should not be the teacher and modeled several roles the teacher can take while conducting discussions, Rebekah's concept of how to conduct discussions was most affected by her field experience placement. It was in her field placement that she analyzed how a mathematical concept was learned and how that understanding was communicated.

The cooperating teacher provided Rebekah with an excellent lens through which she could examine and develop her own teaching beliefs and behaviors. Rebekah was able to note those behaviors she wanted to emulate in the cooperating teacher's approach to discussion, as well as those she did not want to emulate. In her general discussions, Rebekah noted several Standards-like behaviors the cooperating teacher exhibited while conducting discussions. Among these were (a) getting all the students involved, (b) leading the children from broad topics to narrow topics, (c) not criticizing guesses, (d) encouraging students to figure out problems in more than one way, (e) not giving out answers, but asking leading questions to draw the answer out of the student, (f) having students tell her what to do next, (g) putting up incorrect answers to stimulate students to point out her errors, and (h) listening to the students and being able to almost read their minds.

Rebekah was able to compare these ideas with her preconceptions about teaching mathematics and what she was learning in the methods class in order to develop her own teaching style. As this process continued over the course of the quarter, Rebekah's expressed beliefs progressed faster than her behaviors.
One area in which Rebekah's ideas developed was asking questions to engage students in discussion and elicit their ideas. Rebekah's journal comments revealed a growth process in her self-perceived abilities to ask those kinds of questions. In commenting mostly on the daily discussions she conducted after the Newsdepth program, Rebekah noted early how difficult it was directing discussions. She remarked that students tend to go off on tangents during discussion, and needed to work on keeping focused on all students' actions, understanding what the children are saying when they aren't clear, and not asking "fill in the blank" questions. By the end of the quarter, Rebekah sensed she was making progress in these areas when she wrote:

After Newsdepth I led the discussion. For the first time, I was able to stimulate a discussion rather than a reiteration of the facts presented in the show. Although it wasn't a very in-depth discussion, I feel I'm beginning to overcome a great stumbling block of mine. Through experience, I am learning what kinds of questions and how specific they need to be in order to stimulate a discussion and not just get the students to finish your sentences.

Rebekah was aware of her need to develop her questioning skills in order to stimulate discussion. Her cooperating teacher agreed with that development. When describing Rebekah's development with respect to conducting discussions, she said:

Early on I think it was much more directive and for instance when she was working with them or talking with them about Newsdepth, and she would say "what did you think about this," or "what was interesting to you," and somebody would say something, and her responses were more, "uh-huh." And then somebody else would bring up something different, and she would drop that particular subject, rather than thinking of open-ended questions, that they could bring in. I think that she did not have a sense of how to ask open-ended questions, and I'm not sure that I ever used that term with her, but I think that she did start opening up discussion somewhat more at the end.
The cooperating teacher saw improvement in Rebekah's ability to ask open-ended questions, despite not having consciously worked on that skill with Rebekah.

A second aspect of conducting discussions Rebekah worked on during the quarter was wait time. The use of wait time was emphasized in the methods course, but Rebekah did not assimilate this concept immediately. Motivated by her desire to do what the methods course recommended, Rebekah tried to use it early in the quarter. Her description of that attempt helps understand the development process through which she was going.

Waiting for students to give answers is not a natural inclination for the preservice teacher, especially while being supervised. Rebekah expressed the typical concerns of a new teacher, her thoughts being turned inward, wanting to be seen as a good teacher. Being a good teacher at that point meant having students give the correct answers.

A third aspect of interactions Rebekah keyed into during the quarter dealt with the teacher skill of listening. The methods instructor stressed the idea that the teacher must listen to make sure that the students are answering the question that has been asked. She did this both while teaching the course and by comments made to Rebekah after she observed the averaging lesson.
You listened to what they were saying, and your comments were responsive. But learning to interpret what they're saying is a continuing effort. So often it's difficult to understand why they respond as they do -- and it may be that they're answering a different question.

The cooperating teacher reinforced this idea in the comments she made after the same lesson, commenting that by listening, Rebekah would learn about the kids' thought processes. Related to this, the university supervisor felt that Rebekah needed to work on tying the students' ideas together during discussion. She recounted that if "kids were talking about one thing, and another kid took on a different view or idea, Rebekah didn't know how to tie that in, or bring them back on track, or to direct them to where they wanted to go." Later on in the quarter, Rebekah saw the need to work on making sure the students listened to their classmates. She would try to repeat what each student said in class in order to ensure that all the students heard what was said and make sure that students respected each other's ideas.

A fourth aspect of Rebekah's development of her role in conducting discussions involved the question of who would be doing most of the talking in class. All three people involved in overseeing Rebekah's instruction commented that Rebekah's natural tendency seemed to be toward the teacher doing the talking. However, each commented that as a result of having observed Rebekah, they felt that she was trying to draw the students into the discussion and not just be a lecturer. This description was both confirmed and contradicted by Rebekah's expressed intended behavior and Rebekah's observed behavior.

The transcript of the one lesson Rebekah conducted involving exponents indicated that Rebekah asked factual questions or questions that led the student toward the desired result. A teacher/student interaction
pattern dominated the discussion in a form that modeled a Socratic dialogue. The following exchange illustrates the pattern:

Rebekah: Exactly, it is powers. The exponent is your little number up here. It doesn't only happen with 10s. You can have 3 to the fourth power. And your little 4 up here is what you call the exponent. Greg, what would this number equal?

Greg: 12.

Rebekah: 12. This number equals 10, right? What does that number equal?

Greg: 20.

Rebekah: Remember yesterday, we went over what these powers stood for. Does it stand for 2 times 10?

Greg: Two 10s.

Rebekah: Two 10s added together?

Greg: No, it's 10 times 10.

Rebekah: OK, an exponent tells you how many times to multiply the larger number, the base number by itself. So this equals 10 x 10. So what would this number equal, Erica?

Rebekah led the student through a series of questions much in the manner she said she would in her initial interview.

This behavior conflicts with Rebekah's second interview description of what the discussions would be like if she taught a unit on fractions. Her intended behavior would have exemplified a much more student-centered discussion of the concept. She responded to the question saying:

Rebekah: Before doing anything, I would want to build a solid foundation of what is a fraction, and what does a fraction look like and how can you work with fractions. Not necessarily adding them but moving them around, having the different forms fractions can take. Fractions aren't just pies, they're squares, and building just a solid foundation in both, physically what a fraction is in our physical world, but then also building a solid foundation in notation. Because all these kids don't know what the slash means.

Interviewer: What would the discussions look like to build that foundation?

Rebekah: I think I would definitely want them in smaller groups, and would want, I wrote a couple of activities, paper
folding and different ways you can use that. I guess among the students, I could see them presenting their different ideas to each other. Now here's our abstract idea of a fraction, and trying to really pin it down. And I see everybody kind of putting in their ideas as to what they think it is. They may be right or wrong. Really trying to pull all of them together into a right answer, kind of getting rid of the ones that are outright wrong, and I think that would take some intervention by the teacher. I don't think that they're going to be able to do that all on their own. I think that you need to encourage them to build on good ones, good ideas. And we need to encourage them to really analyze the bad ones. Analyze the flaws, not just that they're wrong, but analyze the flaws in bad concepts. So I think the discussion would have to build upon what it is and why the right ones are right and why the wrong ones are wrong. And really pull in from their knowledge.

This response embodies Rebekah's desired behavior concerning discussion. She would like more student interaction, would use manipulative materials to help draw out that interaction, and would have students justify their ideas to the rest of the class. It also points out some of the conflicts that were going on in Rebekah's thinking and her behavior. She wanted to see that kind of discussion as recommended by the methods class, but lapsed into a behavior pattern that followed her initial preconceptions about teaching.

**Summary of Rebekah's Beliefs and Behaviors After the First Quarter**

Over the course of the quarter, Rebekah's experiences in the methods class and the field experience either reinforced or modified her incoming beliefs and projected behaviors with respect to conducting discussions in the classroom. Each of the two experiences had its effect, but there was little coordination between the two components to examine the consistency between the impact each was having on Rebekah's beliefs and behaviors. Rebekah experienced conflict between the theory presented in the methods
course and the practice observed in the field experience with respect to several aspects of the teacher's role in conducting discussions. A summary of those experiences and the changes they affected is presented in the seven categories.

Flow of Ideas. Rebekah's preconceptions included the belief that ideas should come from the students. When Rebekah gave students the opportunity to explore concepts and propose ideas, she was not ready for the response. Students went off in directions she had not anticipated. This challenged Rebekah's naive concepts about the students' abilities to generate ideas and forced her to reconstruct her beliefs about her role in discussions in light of that experience. She moved toward taking a more active part in guiding how ideas are introduced in a lesson, but continued to respect students ideas and ask open-ended questions to promote student input.

Student/Student and Teacher/Student Interactions. Rebekah's intention to take a Socratic approach to questioning was reinforced by the methods instruction and field experiences. The methods class proposed questioning as the primary mode of discussion in the mathematics classroom. Rebekah estimated she was in that mode at least 50% of the time during discussions, supporting her belief that this is an effective method of conducting discussions. The use of small groups as a forum for class discussion was also proposed by the methods class and accepted by Rebekah, despite not being utilized by the cooperating teacher.

Students Justify Their Ideas. The preconception that students needed to justify their ideas was reinforced by the methods class. The methods instructor emphasized the use of the "why" question throughout the quarter. Rebekah was critical of the cooperating teacher's mathematics teaching, because she put more stress on the students' computational skills and less
importance on having students justify their answers. Rebekah's negative reaction to the cooperating teacher's algorithmic approach to teaching mathematics strengthened her perception that students need to understand why they perform operations. Rebekah practiced praising students who were able to justify their answers.

**Acceptance of Ideas.** Rebekah's preconceptions included the beliefs that students' ideas should be respected and ideas are accepted or rejected on the basis of their reasonableness. While maintaining these beliefs, Rebekah had experienced some confusion on how that could be done. She was leery of letting students convince her of doing things "their way," and expressed her need to keep control over the class.

**Tools to Enhance Discussion.** Rebekah was open and receptive to the suggestions of the methods class about the use of manipulatives, problem solving, technology, and student writing. Rebekah recognized the power of technology and manipulatives to offer alternative methods of representing a concept, but expressed confusion about the difference between their use to gain students' interest and to convey a concept. She recognized the importance of problem solving to force students to work together and communicate with one another.

**Teacher Intervention in Problem Solving.** Rebekah believed she would engage students in a series of questions in order to help them overcome obstacles encountered in solving problems.

**Orchestrating the Discussion.** Rebekah had to develop the skill of listening to the students' ideas and tailoring her questions and responses to their input. The cooperating teacher's ability to model good discussion techniques in her lessons outside of mathematics helped Rebekah begin to make those
adjustments. Although Rebekah did not perceive any particular impact on her development through her interactions with the university supervisor, the university supervisor did help Rebekah focus on the cooperating teacher's exemplary behavior during discussion.

Rebekah anticipated that the teacher education program would provide her with almost scientific-like rules on how to teach mathematics. Because of this openness to what the experiences held for her, Rebekah was receptive to new ideas about teaching. The methods class and reading professional literature exposed Rebekah to approaches to teaching she had not experienced as a student and that were not part of her incoming beliefs systems about teaching mathematics. Rebekah expected to be able to implement these ideas in her teaching in her field experience. However, as she attempted to put these new mathematics teaching methods into practice, the reality of the classroom tempered her beliefs about the proposed ideas. Children did not respond as expected. Students did not use manipulatives as designed. Students were not able to initiate and sustain discussions. They were not used to using calculators to justify their answers. The field experiences necessitated a readjustment of Rebekah's beliefs about these ideas.

In summary, Rebekah's incoming perceptions about wanting students to have a better conceptual understanding of mathematics remained intact. She continued to feel she wanted to move away from her own experience in learning mathematics. However, Rebekah did not envision the extent to which that change would take place. When asked what changes occurred in how she perceived discussions taking place, Rebekah replied:

I think the methods [course] gave me a more progressive viewpoint at it. I thought that working in small groups and things like that were great, but I really pictured it to be maybe a once a week thing and not a total
experience. So I suppose it's not that different in the sense that the ideas are the same but to what extent they are permitted and to what extent they are encouraged in the classroom kind of surprised me. I was quite surprised to what extent that was encouraged and to what extent of the day and of your lesson that was really focused on.

The methods class proposed a picture of what the ideal could be, and the field experiences gave Rebekah a picture of what was. Rebekah had to merge the two images together into her own beliefs system. At the end of the quarter, she was still in a state of transition.

Perceptions of Her Role in Discussion After Participation in the General Methods Course and Mathematics Methods Field Experience.

Rebekah's second quarter experiences continued to challenge the naive thinking that Rebekah brought into the program. The differences between the realities of the classroom experienced through her field experiences and the theoretical principles proposed in the general methods class and mathematics field experience seminar was a major source of cognitive dissonance.

Rebekah's desire to see change in the way mathematics had been taught to her and the hope to see the new ideals presented in the Standards implemented in the classroom led to a switch in her field experience early in the quarter. Rebekah had been assigned to a middle school that was part of a university-sponsored program to help train inservice teachers in the teaching methods promoted by the Standards. However, Rebekah felt that the teacher's behavior did not reflect a student-centered approach to learning mathematics and in fact modeled poor teaching methods. Brought to the attention of the university professor, it was decided to switch Rebekah to a different classroom.
Rebekah's new placement provided her a unique opportunity in comparison with other preservice teachers in the program. Rebekah was placed with an eighth-grade teacher in a suburban middle school with three other preservice teachers. The class was divided into four groups and the preservice teachers were responsible for the preparation and implementation of two lessons the first two periods of each day. The first lesson was for what was considered the more advanced eighth-grade class and centered around the teaching of problem-solving techniques. The second lesson was for what was considered a slower eighth-grade class and focused on mathematics skills in preparation for the proficiency examination that the students would take in the ninth grade. Each preservice teacher had the same group of 4-5 students for the entire 10-week period, of which Rebekah was present for 6 weeks. The contrast in the groups provided the opportunity to observe Rebekah interact with students at two different levels, as well as be responsible for a considerable number of lessons, an opportunity not afforded by her first quarter field experience.

The university supervisor observed Rebekah's classroom once a week. Feedback of that observation consisted of a brief 5 minute evaluation of the lesson for the day that included any written observations about the lesson. Rebekah reported she would attempt to implement the recommendations of the university supervisor, but felt that the feedback she received was more often in the form of a question rather than prescriptive techniques that she should perform. In describing the feedback, she said:

Types of feedback. She didn't give much practical feedback. She gave a lot of thought-provoking feedback. Like think about it. So in that sense she pointed you in directions to think, but she didn't give you any help in thinking. She'd ask you how else could you do this. I don't know.
This is my third or fourth try at it and I don't know how else to do it. She didn't give very much practical feedback at all. This reflected again Rebekah's desire to receive direct instruction on how to teach.

The sessions held by the mathematics methods instructor to discuss the *Standards* gave Rebekah an opportunity to find out what other students were experiencing and compare it to her own experience. This was important for Rebekah to hear, because she was concerned about the discrepancies she was finding between the theory taught in the methods class and the practice she was observing and engaging in herself. She acknowledged that the seminars did not discuss the *Teaching Standards*, but said:

> We focused on what was happening to us in the schools, which I thought was very helpful, because it gave me the perspective that gosh, these problems that I’m running into aren't only mine and this was effective for someone else. It gave me ways to - somewhat new approaches to problems that people were actually using in class.

Rebekah needed the opportunities to process the large amounts of information that were being presented in the methods classes.

The instruction in the general methods class was the same as that received by the other preservice teachers in the study. Rebekah felt that the course was geared toward the elementary school preservice teacher, emphasizing the cognitive and social developmental stages through which children go. Rebekah had a hard time relating the material covered to her secondary school experience, stating that most of the teaching examples presented were from the elementary school level. The theory presented did reinforce her understanding about the use of concrete materials to teach mathematical concepts. This reinforcement was observed by the course instructor who commented on how the mathematics preservice teachers
always seemed to be able to connect the general theories presented in the course back to mathematics instruction.

Rebekah was placed with a mathematics teacher during the general methods course high school field experience. The placement was in a predominantly African American inner-city high school. Two aspects of that placement affected Rebekah. The first concerned the mathematics teacher. He was a recent graduate of Rebekah's university, and Rebekah was surprised to see how quickly the idealism of the methods class instruction had worn off. Rebekah was disturbed that students were allowed to sleep or simply tune out from the lesson. She described the situation in this way:

I went into the classroom and there was 5,6 people sleeping every day. I mean dead to the world sleeping. It wasn't like they were trying to fake it, look interested. They were out and I was how can that be? What are these people doing? .... It was kind of scary because he just had these ideas like all of us, of these grand ways your class is going to be and then thinking it's not like that. So it's kind of really scary. So I guess it just reinforced the idea about things aren't going to be as nicely as we might wish but somehow you've got to wake the kids up.

This experience reflects the conflict that Rebekah was experiencing between theory and practice.

The second aspect involved the high school student Rebekah interviewed. The student was taking an algebra course for the third time, and despite passing the quizzes and tests, was going to fail again because of low participation grades for the student. Rebekah was saddened to think that a student she considered intelligent could be so alienated from mathematics. The situation reconfirmed the discrepancy between what ideal practice should be and the reality of the classroom.

The general methods course instructor noted Rebekah's need for structure. Rebekah confirmed that observation by making comments about
the instructor similar to those about the university supervisor in the mathematics field experience. She felt the instructor was never specific enough in her teaching. This, however, became a lesson for Rebekah in recognizing individuals' different learning styles. She reported:

She's very open to the differences in everybody and very accommodating to the differences. In my evaluation I wrote about her. I thought that was the best thing I learned from the class was just what she modeled as far as the differences of people and wanting to flow with the tide. Go with the flow.

Rebekah identified an important point of growth in her ability to deal with the reality of the classroom.

These courses and experiences affected Rebekah's development in the identified discussion categories by reinforcing or challenging existing beliefs and behavior patterns. The seven categories offer a framework from which those effects can be viewed.

**Category 1: Flow of Ideas.**

Since Rebekah had two classes determined to be at different levels, it was possible to see how she reconciled some of the conflicts about who the source of ideas during discussion should be. Three phenomena were observed concerning what seemed to be Rebekah's ideal, what was her preferred mode of practice, and what she would do when outside pressures came to bear on her teaching decisions.

First, her ideal for the flow of ideas in the classroom was that ideas come principally from the students, with the teacher guiding the students' efforts. The flow of ideas would usually be initiated by a problem of some kind that would stimulate the students' interest. Rebekah made the interesting observation that this approach was not being promoted equally in the two small groups she was responsible to teach, because her cooperating teacher
stressed computation for the perceived slower group, but stressed problem solving in the faster group. Rebekah still tried to bring problem solving into the slower group, despite the fact that this sometimes got her into trouble when the group did not cover the range of computational skills desired by the cooperating teacher. In discussing this issue, Rebekah said:

The cooperating teacher did kind of make the statement that they needed more computation than what I was giving them and so I-kind of out of obligation to him-went back to work more computation. And that got me in trouble with the cooperating teacher. So I just tried to form a mixture. I kept bringing in 1 or 2 problems but - yeah in essence we did do problem solving in second period. So I did try to bring it in in both but I thought it was interesting that in second period the concept of problem solving wasn't stressed like it was in first period. I would think in a general class problem solving could be a really fun and exciting way for these kids to get interested in [mathematics].

Observations of her work with the different groups confirmed that Rebekah did begin her lessons with a problem for the students to investigate. Of the lessons observed for the faster group, both were initiated with a problem. In the initial stages of the investigations Rebekah made suggestions and asked clarifying questions as students discussed their ideas. The following excerpt in which students are trying to find how many games there would be in a tournament in which every team plays one another illustrates that point.

Rebekah: For example one problem may be you have five different teams. You have five teams and you want each team to play each other in like a tournament. You're going to have like a round robin tournament and you want to know how many games are going to have to be played. How would you go about figuring that out?

Students: What was the problem again?
Rebekah: You've got five teams and you want -
Student: Make like a graph like this.
Student: Is this a tournament or - you want each team to play each other.
Rebekah: Yeah you want each team to play each other so you're not going to kick anybody out. So again you want to draw pictures of it because things get so clogged up in your mind. So you always want when you can draw a picture -
Student: I think you should just go team A plays team B, and team A plays team C. You know. I don't know.
Rebekah: So you're saying you're going to label them.
Student: Yeah - see Chuck this is it. You can do all of this stuff. But you forgot EE.
Chuck: A,B,C,D,E. Make a graph like that.
Student: Make a graph like that.
Rebekah: So he'd -
Student: He does EA.
Chuck: Do E,A,B,C,D. Right? E - A,B,C,D,E. Then it would be BC DA. BE.
Student: Is that what you're trying to say Chuck?
Chuck: Yes. Did a couple [inaudible].
Rebekah: [laughing]. This is a really good idea. But what happens if you possibly forget a letter? I know you were sitting there stumbling over a letter thinking did I get this combination. How could you be sure that you got them all?
Student: If there's five teams and try to do them all at once. It would be 25 games.
Chuck: Be careful that I didn't miss anybody.
Student: How do you find the five teams?
Student: You've got to play everybody at once. Five times five is 25.
Chuck: No, no. Because a team can't play itself.
Rebekah: So you're saying there's 25 games. Let's write that down.
Chuck: I don't think that's right.
Student: I know it's right. She just messed it up then.

Rebekah's input here indicated that she was willing to let the students generate their own solutions to problems with only guiding suggestions on her part.

However, this behavior did not always persist throughout the entire lesson. In each lesson observed, Rebekah would at some stage go into a form of questioning that would lead the students to the desired solution. This decision to get more actively involved in the discussion verified Rebekah's journal entries expressing her belief that students had a hard time discussing
their ideas mathematically. She remarked that "students seem afraid to do a problem on their own. They are capable of answering specific questions, but have a difficult time deciding what questions they need to answer to do the problem." Believing this, it would be natural for Rebekah to decide to move into a more directive style of teaching when the class reached a stumbling block in solving a problem.

In a problem in which the students were searching for a pattern in summing the first n odd integers, the students were not seeing that the sums represented the squares of the number of terms in the sequence. Rebekah went into her questioning mode to guide the students to see the pattern in the numbers.

Rebekah: Okay 64. Without adding - just looking at these numbers what do you notice about each of these numbers? Do you know anything about square roots?

Student: No.

Rebekah: Okay. Who can tell me what a square root is? If I asked you to take the square root of 4 -

Student: 2.

Rebekah: How did you come up with 2?

Student: 2 + 2.

Rebekah: 2 + 2 is 4 or - Or two times two is 4. So we notice - what two numbers multiplied together equals 1?

Student: Oh yeah. 4x4 is 16.

Rebekah: 5 x 5 is 25.

Student: Oh.

Rebekah: So what do you think the next one is without adding?

Student: 81.

Rebekah: 81.

Student: Then 100 - Then 100 something.

Rebekah: Okay. Exactly. So now we've gotten this pattern going. Back to this number. We want to write our pattern as this equals 1 square. This equals 2 squared. 1 squared means 1 x what? 2 squared means 2 x 2. So on your table write 1 equals 1 squared. So you're not going to be able to do it on the next problem. So you can go 4 equals and then say 2 squared. 9 - okay. So now we're calling for a generalization about this pattern. Okay? How can you relate the sum of
the numbers to the square of the numbers? I want a generalization so that I can find - how can I find like 99 squared? I want this to happen. I want to know how can I add up numbers so it's 99 squared. What numbers would I add up?

Rebekah decided to introduce the notion of squares and square roots to solve the problem. She seemed to have the need for closure to the problem and therefore began a questioning sequence that would lead to the result.

The one thing that Rebekah never wanted to do in teaching was just give the answers or lecture. This was confirmed by Rebekah's actions in class and reinforced by the desires of the cooperating teacher and university supervisor. Rebekah's belief that answers should not come from the teacher were a large part of why she was not able to stay in the class with her original cooperating teacher. Rebekah related one incident in which she was trying to lead students to see that alternate interior angles were equal in a geometry problem, when the cooperating teacher came and told the students the answers. In recounting a tutoring incident in her journal, Rebekah wrote:

Two students asked for help. I sat down with them and at first they just wanted me to give them the answers. I was bound and determined that that was not going to be the case. I grabbed my wedges and began going over the problems with them. I would ask them something and they would just give me a blow off answer. I kept giving them more questions. They seemed to realize that they had to begin to seriously think about this. Before I knew it the two students had stopped slouching back in their seats and were actually leaning over the table looking and touching the wedges. When they got into the activity they began getting the answers.

Rebekah was very determined to have the students become active in the learning process.

Rebekah's dilemma over how to let the students discover concepts for themselves while still maintaining control over the discussion remained
after the two quarters of teacher education. In her final interview she said that:

I still think it's important to have discussions and I think it's still important to let them discover it. But I think I realized from experience I need to be much more involved in directing. I thought they would direct themselves much more than what they do.

Category 2: Student/Student and Teacher/Student Interaction.

The interaction patterns Rebekah developed in her classes between herself and her students and among her students followed from her beliefs and behaviors about how ideas should be developed in the classroom. Two principal patterns emerged from the analysis of the data involving how Rebekah interacted with the students and what she did in order to promote verbal interactions among the students.

Rebekah's principal pattern of interaction with students, as previously identified, was questioning. Throughout the quarter, several behaviors became apparent in Rebekah's questioning habits. The type of questioning that Rebekah initiated depended on whether the students were exploring a problem together or whether a specific answer was being sought. First, Rebekah worked on posing her questions based on the responses of the students to previous questions. This behavior was more apparent when the students were engaged in cooperative problem solving. One of her self-determined objectives for the second quarter in the field experience was to "become more in tune with the children so as to be able to evaluate their understanding of what I am trying to convey to them." The university supervisor, the cooperating teacher, and the general methods instructor each observed Rebekah's efforts and needs to be sensitive to individual student's responses during discussions. The university supervisor commented that:
I felt she was really working at questioning. When a student would ask her a question I would see her stop and, you know how a person looks like they're thinking, and she would come back with a question to the student, and then the student would either answer or ask another question, and again she would answer with a question, and I felt that she purposely had this in mind that she should give questions as answers rather than answers.

An example of this was seen as Rebekah interacted with students during the solution to a word problem.

Rebekah: So we have the Sherman family has a pool 30 feet long and 25 feet wide. There's a walkway 4 and one half feet wide around the pool. What's the perimeter of the pool?
Student: 30 feet - times that by 2. It would be 60. 25 feet wide. Times that by 2. It would be 50. So it's 60, 50, 110. Yeah. 110. The walkway around the pool. They just want to know -
Rebekah: Wait, wait. What's the perimeter of the pool? I'm lost here. What are you doing?
Student: 30 -
Student: See look. There's three sides, I mean there's two sides like this. Say this was the pool. This is 30 and this is 30. I'm timesing it by 2.
Rebekah: So you're saying 30 times 2?
Student: And this is 25. 25 - so it's 30 times 2 which is 60 and then 2 times 25 which is 50.
Rebekah: So we've got 60 and we've got 50. We add them together and it's 110.

Two behaviors that Rebekah employed in her discussion in this sequence were asking for clarification and restating what the student had said in order to confirm what she had heard. Both of these behaviors indicated that she was listening to what the students said.

Second, Rebekah entered into a questioning pattern that resembled recitation when trying to obtain a particular answer. This type of questioning was the typical pattern when working with the slower students and was employed with the faster students when obstacles were encountered in their problem-solving efforts. Rebekah used a series of questions that elicited
individual steps in the problem-solving process. For example, after the students had worked on the team tournament problem with little success. Rebekah initiated the following sequence of questions:

Rebekah: Okay. You said there was going to be 25 teams. Let’s see if you’re right on that.
Student: Wait a minute. No. I’m wrong.
Chuck: I knew he was wrong.
Rebekah: If I drew your teams like that how would you think you could draw a picture for each of the games they played?
Student: Make lines to each one. Make different types of lines - one straight.
Rebekah: If team A was going to play team B what would I get? Draw a line between? And that would be one game.
Student: Uhhuh.
Rebekah: But now we know team A has to play each of these.
Student: So make straight lines to every one of them.
Rebekah: Team A has played everybody. Has everybody played team A?
Student: Yeah.
Rebekah: Okay. How would you complete this - Stewart? With our diagram like this how would we -
Student: Team B and make like double lines. Different types of lines.
Student: But just don’t go to A again.
Student: Yeah.
Chuck: Make them dotted.
Rebekah: A dotted line.
Student: Give them all different lines.
Student: And then a dotted line to D. And E.
Chuck: And [inaudible].
Student: Not to A.
Student: Make a squiggly line from C to B.
Rebekah: And what else do we need to do?
Student: From D to E.
Chuck: I was right.
Student: Hey man, looks like a pentagram.

Rebekah initiated the solution method that she wanted to see used and then asked questions to lead students to the solution.

This questioning strategy was used during normal sequences with the slower groups as well. The focus of these groups was computation, so
Rebekah concentrated on helping the students develop their skills. For the last five weeks of the quarter the students worked on a unit on fractions, beginning with equivalent fractions and ending with multiplication of fractions. In a sequence of questions trying to solve a problem that required the subtraction of a mixed number from a whole number, the following exchanges took place:

Rebekah: How did you come up with 5/6? What did you do when you did that though? You subtract that 4 1/6 from 5? Is that what you did? You had 5 pounds. You used 4 full pounds, right? We know that much. So after we use 4 pounds of our 5 pounds how many pounds do we have left?

Student: One pound.

Rebekah: We've used 4 of our 5 pounds. So you've got 1 pound left. And you also have to use 1/6 of that pound. You basically - so 5 minus 4 1/6 tells you how much is left over.

Student: How do you subtract 5?

Rebekah: You want to subtract 5 from 4 1/6 or do you want to subtract 4 1/6 from 5?

Student: 4 1/6 from 5.

Rebekah: Okay. How would you do that?

Student: I have no idea.

Rebekah: Ray - set up your problem as far as you know. When you take 4 away from 5 how much - you've got 1. But don't forget you also take your 1/6 away from it. 1 minus 1/6. What does 1 equal?

Student: Six sixths.

Rebekah: So you've got 6/6 and you take away 1/6. How many sixths are you going to have left over?

Student: 5/6.

Rebekah asked leading questions to take the student through the steps to arrive at the answer. It seemed that Rebekah was using a large-class/recitation approach to conduct discussions during these classes. This was the general mode that she entered into after introducing a problem or going over homework.
Third, Rebekah's intended behavior and attitudes toward student involvement in discussion did not agree with this mode of leading the class discussions. In her interviews and journal writing, she consistently expressed a desire to use cooperative groups to involve more students in the discussions and noted those occasions when such groups were effective. She stressed how teaching a small group allowed her to personalize the lessons to the needs of the students and promoted student thinking, something she didn't think possible in large-class discussions.

Equally consistent were her comments indicating perceived pitfalls to the use of small groups. When asked if she would use small groups in class, she said:

I think I would still use small groups but I think I would really be cautious of grouping people with a mixture of abilities. I wouldn't want all the good students in one group and all the poorer students in another group. I really think I'd be cautious of getting a mixture in so that hopefully some of the higher achieving students would try to like - there might be a leader of the group. I think so much depends on leaders. If you haven't got leaders you've got chaos. If somebody isn't willing to kind of guide the discussion. I wouldn't want that one person to be doing the discussing. So I think mixing the groups would be very important if I couldn't be there with each group so much.

Her perception of needing leaders in the groups reflected her decision to be the leader in teaching her small group throughout the field experience.

Rebekah did recognize that initiating students to participate in discussions that were not directly led by the teacher was important to their success. In her interview, Rebekah reported how the students showed resistance to participating in discussions. Among her observations of how the students reacted to being asked to verbally communicate their mathematical ideas, she said the students preferred showing her what they did, not telling how they did it. She was surprised to see that they needed
practice at this behavior. Most students would work individually in a group, instead of working together. In one lesson, she purposefully used a card flip activity to initiate student discussion. She felt that her efforts had produced some success with the students, because she found that they were beginning to work together by the end of the quarter. She commented:

In the beginning they didn't want to say anything and after she practiced they started talking and they got to the point where if they knew something they were willing to go kind of more out on a limb and say look, this is what I'm thinking. And they got used to me saying why did you do it that way. How did you do that? Or is that the right answer? In the beginning they were like oh I did it wrong and would erase it. I didn't say you did it wrong. You didn't need to erase your whole problem.

Rebekah's students had progressed from being unwilling to participate to being able to participate and defend their positions.

**Category 3: Students Justify Their Ideas.**

The fact that Rebekah had a tendency toward a pattern of teacher/student interaction dominated by leading questions did not inhibit her from continuing to ask questions that elicited students' understanding of the concepts being taught. Rebekah developed several techniques of having students justify their answers. Besides asking students the "why" question, she required students to justify themselves by (a) asking students to convince her of what she was saying, (b) asking the students if they were positive about their answer, (c) having students describe their responses more completely, and (d) asking how a student came up with an answer. Rebekah noted that she did this not only when a response was correct, but also when the response was incorrect. By doing this she found that her:

students aren't so panicky if I ask them how did you do that or is that right. I always ask them. That's the one thing that my students always respond to me, is they don't panic anymore. They say, yeah, that's right.
Having students justify their answers continued to be a priority for Rebekah.

The extent to which Rebekah would ask for justification depended on several factors. First, the readiness of the students to participate in discussion was a major factor. The students in the "advanced" group were perceived to handle those kinds of questions more readily, making it easier to enter into that kind of questioning with those students. The fact that students in the slower group were not accustomed to justifying their answers presented a problem to Rebekah. In one journal entry she expressed her frustration with the students in the slower group who would not accept that their ideas were incorrect.

I was trying to show them that their answer was incorrect and there was a couple of them they seemed to tune me out and try to argue that they had the right answer. I say argue because they wouldn't give me a reason [except because that's how you do it] why they could do it. Had they given me a reason, I could have tried to correct their misconception. But as it stood, I could only say that doesn't work and there is how [and why] it does work.

This difficulty forced Rebekah to make a decision about whether to persist toward having students justify their answer or go into a demonstration mode of teaching. Rebekah decided to go into a demonstration mode that showed the students with the reasons why. That decision explains the frequent questioning form of recitation that Rebekah used in discussion.

A second factor that deterred Rebekah from asking students to justify their answers was the lack of conceptual understanding of the students. One goal for discussions in her classroom was that students display that they were thinking about the concepts. She was frustrated by students who would perform algorithms mindlessly. She preferred to have a discipline problem with a student, as long as they were actively involved in the class, than to have a student who showed no interest whatsoever.
Category 4: Acceptance of Ideas.

The teacher who promotes student involvement in the generation of ideas needs to have a plan for what to do with the ideas as they come up in discussion. First, Rebekah wanted students to feel free that they could share their ideas in the classroom. This belief was reinforced by the cooperating teacher and the general methods instructor. Although Rebekah did not say they did, she worked with the cooperating teacher worked on developing that specific attitude. The cooperating teacher said he stressed making the students feel comfortable enough to be able to ask questions in class. The openness the general methods instructor modeled toward the differences in students' thinking made a positive impression on Rebekah.

Second, Rebekah stressed that there could be more than one acceptable solution to a problem. On one occasion, after the students had successfully completed a problem, Rebekah demonstrated a second approach the students could have used. When the students questioned why she hadn't demonstrated the method before, Rebekah emphasized that there was typically more than one way to solve a problem. She demonstrated on that occasion that she could accept students' ideas even if they were not the most efficient. This did not mean that she was ready to abandon her planned lessons to follow up on students' solutions. In her lesson on comparing fractions, one of the students devised an interesting method to compare 3/4 and 6/10. The student saw that 1/4 was greater than 2/10, and reasoned that 3/4 would have to be greater than 6/10. Although Rebekah praised the student for finding this method, Rebekah proceeded to pursue her lesson plan that had students look for a pattern in the cross products of the fractions, a process that she led the students through step-by-step. In other interactions
with the students, Rebekah would acknowledge a student's answer, but rarely explore the response if she didn't see an immediate link to where she wanted the discussion to go.

Third, Rebekah let students know that the teacher was not infallible by admitting to her own mistakes. She encouraged the students to challenge her ideas. When one student found it distressing that she did not know a word was not in the book's glossary, she felt the experience would help the student build self-confidence in their own thought processes. On another occasion, while working with fractions, Rebekah made the statement, "You've got a pie sliced into 91 slices. You've got 98 of them." A student pointed out that you could not have 98 pieces of something that was cut into 91 slices, and Rebekah said that she had made a mistake in communicating her thoughts, modeling her acceptance that the teacher is not always correct.

Fourth, Rebekah's basic plan for accepting or rejecting ideas was based on the students' ability to justify their thinking. After having told the students there was more than one way to approach many problems, she had the following exchange with one of the students:

Rebekah: Well no. This is a very valid way. I'm just saying there is more than one way to do a lot of things. There's usually - typically there's more than one.

Student: It's right in my mind.

Rebekah: Yeah, and that's what matters, right. It's right in your mind, but you have to be able to convince somebody of your answers. You have to be convinced of it in your mind and you have to be able to convince somebody else, which is basically what you just did by saying look, this order fits all of the constraints.

For Rebekah, acceptance of ideas was based on sound reasoning, and whether the other person can be convinced that it is acceptable.
Category 5: Tasks That Promote Discussion.

Rebekah clearly understood the need to provide tasks that would get the students' attention and stimulate them to contribute to the class discussion. She also saw that getting their attention would not necessarily get the students to think, a shortcoming she felt the general methods class did not address. Rebekah expressed her beliefs about this during her last interview.

I did one problem where the end goal was finding out how old I was. It was really funny because the problem came exactly out of the book, except I just noticed that my ages fit into the same pattern, which was just by luck. But changing the problem from being just from somebody they didn't care about to finding out how old I was, they found it really neat and they thought. Even some of my students who just sat through class all the time that I was there and I would struggle to get them to think about anything, just them being curious made them really care and it showed in their discussion. What they had to say. It really got their brains going so I think that's important. I think it's important to make it something that they are capable - one specific time we were talking about something and they had no idea what I was talking about and all of a sudden I'm going, wait a minute. These kids don't know what I'm saying. It was weird for me because I just always assumed they would know but they didn't. So clearly for them to be able to discuss it. To be able to think about it and not just something that totally blows their mind. It has to build on what they know and to continually push them. Okay, you know what you're talking about but let's push it to the edge of what don't you know.

Rebekah's naive beliefs about the level of interest and ability of the students was again challenged, and she was required to restructure her thoughts about what students were capable of contributing in a lesson and what would enable them to be ready to contribute.

Rebekah's experiences at the middle school reinforced her idea that learning computational skills were not sufficient to interest the students. Providing interesting tasks for the students was the first step in engaging the students in discussion. Although she attempted using calculators, playing games, having students make posters, and having students write about their
understanding of mathematics, the two most prominent methods she used to engage the students' interest was the use of problem solving and manipulatives.

Rebekah saw problem solving as a method of personalizing mathematics for the students and making mathematics relevant to the real world. Rebekah did this frequently in each of her two groups while teaching during the second quarter. It was relatively easy, because problem solving was the focus of the advanced group. Here it was expected of her. However, in the slower group, where the focus was computation, she persisted to offer problems as a means of generating student interest. She remarked on the distinction in attitudes toward the two groups in an early journal entry.

2/5/93. Today I worked with a group of students during 1st period. The personalities of this group are dramatically different from my second period group. My second period group has a general attitude of hopelessness. I wonder if the topic doesn't explain some of the differences. In first period we are learning about problem solving. In second period we are learning about GCF's [Greatest Common Factors] and LCM's [Least Common Multiples]. I think problem solving is much more interesting.

During her end of the quarter interview, Rebekah remarked:

Like I said with first period most of the time when I was there we were doing the chapter on problem solving. First period was the more advanced class. I don't know if it was technically an advanced class but in comparison to the two classes it was the higher level one and I thought it was really surprising that in second period we did not do problem solving. That wasn't a part of the chapters.

Rebekah tried to compensate for that by putting many of the computational skills being taught in the second group into problem-solving situations. In one sequence of problems, she challenged the students with a problem about feeding her dog. First, she wanted to know how much food would be left in a can if 1/3 of the can was already used and she fed 1/4 of a can to her dog for
dinner. Then she asked if she could feed the dog again from that can. She did a similar problem about how much bacon was needed for a lasagna recipe.

A second technique Rebekah learned through the mathematics methods class and seminar was to personalize the problems. Although she basically followed the textbook for homework assignments in both groups, Rebekah would make the computational problems personal by talking about her dog, sharing her recipe for lasagna, or adapting the problem to the personal characteristics of the class. She noted that this increased the students' interest and increased student understanding. In spite of the success she saw using problem solving, Rebekah was still concerned she was not seen in a good light because of not going over the computational skills as fast as the other preservice teachers. The stress on computation was sending mixed messages to Rebekah in the field experience.

The second choice of task Rebekah focused on during the quarter that affected discussions was the use of manipulatives. They were stressed in the mathematics methods course, and Rebekah tried to practice their use in her teaching experience. Rebekah felt that students were better able to explain their ideas when they had something in their hands and could demonstrate what they meant. Without manipulatives, students just showed examples of what they meant, but could not explain it verbally in mathematical terms.

Because the unit she was working on was fractions, Rebekah already had some experience with the kinds of manipulatives that were used. She brought in fraction wedges to allow the students to compare fractions, and would sometimes demonstrate concepts using icons of the fractions wedges. For example, Rebekah used diagrams to demonstrate that seven-thirds was equal to two and one-third.
Rebekah: Your whole integers are called whole numbers, because they are wholes. So a mixed number is a combination of a whole number and a fraction. How many wholes are in 7/3?

Student: Seven.

Rebekah drew three circles on the board, dividing them into three parts each. She then counted:

Rebekah: 1, 2, 3. 1, 2, 3. So we've got six and we only need one here. So how many wholes are there?

Student: Two.

Rebekah: Two. What else do we need. We need a 1/3. So you write it as 2 and 1/3. That means 2 and 1/3, but we don't write it there. Derek, how do we write 7/2? Come to the board and write out your circles just like we did for 7/3. Write your circles just like I did.

Student: What?

Rebekah: Did you see what I did?

Student: No.

Rebekah: Why not?

Student: What's the 7. It's all 7/3.

Rebekah: OK. Now we want 7/2. How many halves do we have up here? Because we've got two there. How many do we have here.

Student: Two.

Rebekah: How many do we have in both of these?

Rebekah initiated this behavior to demonstrate the concept, but did not always have the students do this. In going over homework at the end of the quarter, Rebekah used the symbolic form of fractions in converting improper fractions to mixed numbers without referring to the iconic representation of the problem.

This confirmed Rebekah's tendency toward prematurely moving from the manipulative representation to the symbolic representation. In teaching the students about comparing fractions, Rebekah started the lesson by letting the students compare fractions using the fraction wedges. However, in that
same lesson, she tried to convince the students they didn't want to use
manipulatives every time they wanted to compare two fractions. She said:

Now each time you have two fractions, do you guys want to pull these
things out to determine which one's larger? No. So let's see if we can
find a pattern here going on. We're going to apply a little trick. We're
going to look for a little pattern.

Rebekah seemed to think that a brief exposure to the manipulatives would
provide the foundation necessary to move into the symbolic form of
comparing fractions. She had decided to have the students look at the pattern
of cross products to compare the fractions.

This use of manipulatives indicated some confusion about how
manipulatives can be used to help students develop concepts through
Bruner's concrete, iconic, and symbolic levels. Rebekah recognized and used
the three levels, but did so in a way that did not sufficiently allow the
students to internalize the concept at any one level. When asked to discuss
manipulative use in the final interview, Rebekah expressed satisfaction in
using fraction wedges, but that her last lesson on multiplying fractions had
raised concerns about manipulative use. Using a strategy to teach fraction
multiplication she had taken from the previous quarter's readings, Rebekah
found the students were uninterested in the manipulative. She felt this was
due to the fact that the teacher had taught the rule for multiplying fractions
the day before. However, when asked how she would have proceeded had
that not been the case, Rebekah responded:

You know I don't really know. I don't know how to say it. That, I think,
is my biggest problem. I have a problem connecting how to make that
transition from manipulatives to the computation because, of course, we
don't want them folding paper every time they go to multiplying
fractions. And that's my biggest complaint about the standards. About
the classes, about methods. About the whole program is we haven't
been given enough feedback as to how to make those transitions. I really
Rebekah expressed confusion about making the transition from manipulative use to symbolic representations that had not come out in the methods class or in the second quarter's field experiences.

**Category 6: Teacher Intervention in Problem Solving**

Rebekah was concerned about how students felt when they confronted obstacles in solving mathematics problems. This concern carried over from her preconceptions about teaching. She felt she needed to show students she cared about how they were doing problems and was available to help them when they needed it.

Rebekah responded to students who were stuck on a problem in two ways that were typical of what teachers do short of giving the student the answer, an unacceptable approach for Rebekah. First, Rebekah would enter into a questioning mode to bring the student back to a point of understanding. This approach was supported by the university supervisor who told her on one occasion where Rebekah was unable to address a student's question that she needed to address the two aspects of the concept through simpler problems. An example of Rebekah applying this notion can be seen in this brief exchange in which a student was subtracting one-fourth from five and got one. Rebekah began questioning the student, saying:

"Let's just look at the problem. Can it possibly be 1? We've got 5 wholes and we're only going to take part of one whole. Could we possibly lose all four of the wholes?"

Her questions brought the meaning of the concepts to the students' attention in smaller parts in order to demonstrate the larger concept. In her journal
she wrote, "As [the students] got stuck, I would ask them questions that would lead them in the right direction."

The second strategy was giving the students hints. This approach was supported by the cooperating teacher and reinforced by another preservice teacher who modeled the behavior in a class Rebekah observed. Rebekah tended to give the hints while the students were in a problem-solving mode, looking for something to spark the students' understanding to help them unblock their thinking. Rebekah occasionally became frustrated when students were not able to come up with a solution, and then she resorted to giving hints to direct the students.

One final observation about Rebekah's behavior when students were not understanding a particular concept was that she would try to explain the concept using less rigid mathematical language. For example, in her lesson on comparing fractions, one student forgot the meaning of the term "denominator." Rebekah told her that it's the number on the bottom. She suggested the student could remember that because the denominator goes down below the fraction bar.

Rebekah had insight into the problem of helping students remember the meaning of concepts. In her journal, she wrote:

Two of the three students had forgotten how to compute the perimeter. I told them if they have forgotten what the perimeter is, they better look it up. Once they did, the problem became trivial for both the students. This really shows me the importance of integrating mathematical topics. This allows the students to constantly review material but also presents the concepts in various formats. Not integrating, I think, allows students to only expect certain questions in a certain format. This allows students to focus on non-relevant key-words and then when the student comes across the concept in a different format and the key-words are not present, the student cannot make the connection between the concept and its meaning.
Her understanding that connecting mathematical concepts could help students focus on relevant instead of irrelevant attributes of the concepts they struggled with was profound, but could possibly be lost if she did not analyze her behavior in conducting discussions to see if it was consistent with this insight.

**Category 7: Orchestrating the Discussion.**

Because there was little immediate feedback given to Rebekah during the quarter, her approach to directing a discussion did not seem to undergo any radical changes. Her behavior depended on the particular task under consideration, how Rebekah perceived the ability of the students to respond to the task, the time Rebekah had to prepare for teaching the task, and the perceived amount of time available to teach the remainder of the lesson.

Listening to the students was one teaching skill Rebekah worked on during the quarter, and one she identified as being important for her to continue to develop to become effective in conducting discussions. In her final interview, when asked what would help her develop the skills she needed, she replied:

> I need to better understand where the kids are coming from. I think that would come from working with them more. I found that sometimes I over-anticipate and sometimes I under-anticipate what the students know and what they're going to come into the lesson with. So I think I need to concentrate on that.

Rebekah demonstrated a willingness to abandon planned lesson procedures if students were not able to understand what she was trying to communicate. Early in the quarter, during a lesson on comparing numbers, she realized she was speaking over the students' heads, so she moved back to representing the points on a number line, and using their position as a point of reference to compare the numbers.
Rebekah's major mode of behavior in leading discussions was to use leading questions to direct the students toward the concept being examined. This mode of behavior was Rebekah's "default mode" of conducting discussions. When she ran into a situation in which the students were no longer able to move themselves in the desired direction, Rebekah would begin to ask questions to bring them there. In a lesson on finding the number of diagonals of an n-gon, Rebekah asked the students to find the number of diagonals in an 11-gon. When four different answers were given, Rebekah decided to intervene:

Rebekah: Out of all four of us we've got four different answers. So does everybody agree this is a pretty bad way of going about solving this problem? We can make a table and maybe see a pattern. So we want to make a table. We're going to make a two-sided table. What would we want to put down the first column? If we were to organize what we just did counting our number of diagonals, what would we want in the first column to be?

Although not a lecture, the form of questioning communicated that there was an answer being sought. While doing another problem on the same day with the more advanced of her two groups, Rebekah walked the students through a series of questions that led to the solution of the problem. The problem involved solving the sum of the odd integers from 1 to 99.

Rebekah: In the first line how many odd integers do you sum together? In the first one. 1 equals what? How many do you add together? It's just 1. In the second case how many are we adding together?
Student: 7.
Rebekah: In the third case.
Student: 4.
Rebekah: In the fourth case? In the fourth case the answer is what squared?
Student: It's 4 squared.
Rebekah: It's 4 squared. So do we see a pattern going on here? You added up the first four odd integers and we got 4 squared.
Does that pattern continue? Chuck, does that pattern continue?

Chuck: Yeah. I suppose.

Rebekah: You suppose. Well where's your pattern? Does it happen in each of those cases?

Chuck: Yeah.

Rebekah: So how would you find 99 squared? What would you sum together?

Student: 99 -

Rebekah: The first 99 odd integers. Exactly. So make a generalization about our pattern. What did we just come up with on our pattern?

Student: [inaudible].

Rebekah: We're talking about 99 squared so that's very specific, right? So we want a generalization. We want something that you can generalize. In our pattern what's going on in each case?

Student: For every odd number it's that number squared. For two odd numbers it's two squared. For three odd numbers, it's three squared.

Rebekah: Right. So - state our generalization.

Student: So the first 99 odd numbers, it's 99 squared.

In this mode, Rebekah dominated the discussion and led the students by her questions. The students were no longer in an exploratory mode, but were following the lead of the teacher.

On one occasion, Rebekah had not been asked to prepare a lesson to go over the rules for addition, subtraction, multiplication, and division of integers. Since the time was short, Rebekah decided to lecture the students on the rules. Rebekah followed the example of most teachers who have insufficient time to teach a topic: she reverted back to a method she rebelled against when first coming into teaching, giving the student the answer.

Summary of Rebekah's Beliefs and Behaviors After the Second Quarter

By the end of the second quarter, several aspects of Rebekah's beliefs and behaviors about her role in conducting discussions emerged. Rebekah had expected the teacher education program to be more prescriptive in nature,
providing more concrete methods. The lack of concrete examples from the mathematics methods and general methods courses and little direct feedback by the university supervisor and cooperating teacher forced Rebekah to assimilate her experiences and apply them to her teaching on her own. This resulted in expressed beliefs that reflected the letter of the Standards, but in behaviors that did not always reflect the spirit of the Standards. Results illustrate this phenomenon in several key areas.

Flow of Ideas. Rebekah's ideal for the flow of ideas in discussion remained from the students precipitated by some problem situation. Rebekah introduced many lessons with problems, allowing them to investigate avenues of solution on their own, but generally intervened with leading questions when they got bogged down. Rebekah felt it was important for them to discover, but that she needed to be more involved in directing the students to the solution.

Student/Student and Teacher/Student Interactions. The principal interaction mode in Rebekah's classes was teacher-led questioning. Although she only worked in small groups, Rebekah's behavior resembled the kind of questioning in a full-class recitation. Rebekah believed she would still use small groups to promote interstudent discussion, but was concerned about having someone to guide the discussion. Otherwise the group discussion would become dominated by one person. Rebekah felt students needed initiation in participating in discussions.

Students Justify Their Ideas. Rebekah believed students should justify their responses whether or not they were correct. She reported the progress made by her students in this area at the end of the quarter. Students were no longer reacting negatively to being asked to justify their responses. This type of
intervention occurred less with the slower students than with the advanced students.

**Acceptance of Ideas.** Rebekah continued to strive to create an environment in which students were free to contribute. Rebekah acknowledged the fallibility of the teacher in order to demonstrate that ideas are accepted not on the basis of who gives them, but on the basis of their reasonableness.

**Tasks That Promote Discussion.** Rebekah believed her task was to engage students in mathematical thinking. From the beginning of the study until the end of the second quarter, Rebekah consistently expressed the desire to engage the students' intellect. One way Rebekah's behavior reflected this was in her choice of tasks. Rebekah continually challenged students to solve problems in both the classes she taught. She used the technique of personalizing the problem to further interest the students. Rebekah used manipulatives in many of her lessons to promote students' conceptual understanding of mathematical concepts. During her lessons on fractions, she had the students use fraction wedges to compare two fractions and illustrate multiplication of fractions. However, Rebekah had a difficult time in establishing the link between the manipulative representation and the symbolic representation of the concepts. In the lessons mentioned above, Rebekah moved directly to the symbolic form of the concept before students were able to establish links for themselves. This in turn did not enable students to utilize manipulatives or icons of manipulatives in discussions to justify their ideas about fractions.

**Teacher Intervention in Problem Solving.** Rebekah exhibited two methods of intervening when students got stuck. One was to enter into a form of questioning to bring the student back to a point of understanding. The second
was to give the student hints. Rebekah sometimes used less rigorous language with the students and provided memorization aids to help remember mathematical vocabulary. This contradicted her insightful observations about making mathematical connections as a means of forming conceptual understanding.

**Orchestrating Discussions.** Rebekah expressed the desire for discussions to be student-centered with the teacher orchestrating discussions by listening to students' ideas, asking students to clarify their ideas, and deciding which of the students' ideas to pursue. Rebekah practiced the skill of listening to her students' responses during the course of class discussions. This skill was targeted by Rebekah at the beginning of the quarter as one of her learning objectives. Her behavior and comments by the university supervisor verified her progress in this area. However, her principal mode of conducting discussions was to ask leading questions. Whenever students were no longer progressing toward the solution of the problem, Rebekah entered into a questioning mode that led the students to the answer. Although this behavior was consistent with the emphasis on questioning in her mathematics methods classes, it was not consistent with recommendations by the *Standards* that emphasize a student-centered form of discussion.

In summary, Rebekah entered the mathematics education program with naive ideas about her role in conducting discussions in the classroom that were challenged by the reality of the classroom and mathematics methods instruction. Her belief in engaging the students in Socratic questioning remained intact over the course of the two quarters. The potential conflict between her ideals and her practice in these areas was not brought to Rebekah's attention through her contacts with the university supervisor or
cooperating teacher. Rebekah had expected to receive direct instruction on effective teaching practices. Instead, she formed naive ideas about new methods of teaching mathematics that were challenged by the realities of the classroom. Keeping discipline, teaching for the proficiency tests, having students who didn't care and couldn't express their ideas left Rebekah wondering how to get students involved in discussions about mathematics. Her professed interest in engaging the students' intellect and challenge their thinking was tempered by a tendency to enter into directive questioning in which students were led to the desired result.
CHAPTER VII

THE CASE OF DAVID

Background.

Of the four students in the study, David was the only student who emphasized the influence of one of his teachers on his decision to go into teaching. During his last three years in secondary school, David had the same woman as his mathematics teacher. She encouraged him in his pursuit of a career in mathematics education once he decided he would like to become a teacher. Beyond the teacher/student relationship, David felt this teacher treated him like an adult and was a friend and confidant. He visited her office often to talk about teaching mathematics. David maintained contact with his teacher once he arrived at the university and visited her when home on vacation.

David had a strong academic background. He took mathematics each of his six years in secondary school. He used the Saxon series mathematics texts for his Algebra 1, 2, and 3 courses starting in eighth grade, took geometry his junior year, and finished with calculus during his senior year. David carried an overall G.P.A. of 3.55 and a mathematics G.P.A. of 3.5 at the university.

Despite this strength, when he entered the mathematics education program, he was not sure of his ability to teach the upper levels of high school mathematics. He based this feeling on an experience in which his
former teacher asked him to teach a calculus class on one of his visits. He felt unsure about his recollection of the concepts involved in calculus and felt he would have to familiarize himself again with those ideas.

David's preconceptions of teaching mathematics were based mainly on the model of teaching demonstrated during his last three high school mathematics courses. When asked how he would handle various situations in teaching a mathematics class, David invariably felt he would do what his teachers did. He often referred to his experiences as "what I grew up on," or "that's what I was raised on." In responding to a question about aspects of teaching the first interview did not address, David said:

Right now I am going into education and I know I haven't formulated these ideas, what I want to do and how I want to teach. I don't know yet. That's what I'm hoping to learn in the next couple of years. So all these questions that you ask me I think I've based all my answers on what I've seen. That's probably what I would use right now. What my past teachers have done. So I don't know yet.

David's positive experiences as a learner with a teacher perceived as a strong role model provided David with a basis from which to develop his own teaching beliefs. David wanted to keep an open mind about what he anticipated learning during the next two years in the mathematics education program, because beyond what he had experienced, his own teaching perspective was nebulous.

**Incoming Experiences and Beliefs Concerning Discussion in the Secondary School Mathematics Classroom.**

David had high praise for the secondary school teacher who influenced his decision to enter mathematics education. Because of his positive experience at the secondary level, David's preconceptions about conducting discussions in the mathematics classroom mirrored the behaviors of his
teacher. His experiences and related beliefs about his role in mathematics
discussions are recorded in the seven categories.

**Category 1: Flow of Ideas**

David saw himself as the leader in class discussions. He expressed the
intention of "taking charge" of discussions. He felt that he learned best when
the teacher would show him "exactly how to do something." David's
intention to mirror the actions of his teachers indicated he would be the
initiator of ideas in the mathematics classroom. David described his teacher
as the leader. When asked to describe class discussion, David said, "She
obviously was the leader in the classroom. She introduced everything,
started everything up." One of David's typical classes depicts almost the exact
scene from Goodlad's, *A Place Called School* (1984). He said the teacher
would go over the homework from the night before, lecture the students on
the new material, do examples of the new concepts just introduced, and go
over other examples with the students before allowing the students to work
on the next night's homework. This class scenario depicts a class in which
the students are passive recipients of information transmitted by the teacher,
a picture David identified with and accepted for lack of other models.

When contrasting discussions in an English class with those in
mathematics class, David remembered getting into debates in English classes,
something he did not do in mathematics. David felt that more people have
ideas to contribute to an English discussion than they do to a mathematics
discussion. This restricted view of student contributions correlated with his
view of the teacher as taking charge of discussions.

In one instance in high school, David recalled teaching a lesson he
taught in which he went over homework problems with the other students.
During the lesson a student raised a question about how to factor a particular type of polynomial. David remembered being confused at that point, because he was unable to answer the student's question. After appealing to his own teacher, he concluded that there were some mathematics concepts one learns just by doing them. David assumed he was still in charge of the discussion at that point, but knowing how to do something and not being able to explain it to the other students caused conflict in David's image of being a teacher. Being a teacher for David meant having the facts and being able to share them with other students.

**Category 2: Student/Student and Teacher/Student Interactions**

Because David's mathematics classes were teacher centered, lectures were the principal mode of transmitting material. Teacher/student interactions occurred when students were given the opportunity to pose questions during the time examples were being given or while going over homework. When students had particular difficulties doing an exercise, David's teachers would "work us through [the problem]." By working the students through the problem, David meant the teacher would start the problem, then ask questions until the students arrived at the right answer.

Student/student interactions occurred when David's teacher called students to the board to go over examples. Other forms of student/student interactions, such as working in small groups, were almost nonexistent. David could not remember ever working that way during his last three years, except at the end of the period when the teacher would allow students to work together on the homework assignment.

Despite not having worked in small groups, David felt he would use them in the mathematics classroom given the opportunity. He commented
that the small groups depicted in Scenario I on the screening questionnaire obviously worked. He felt they motivated students and generated questions among the students. David felt small groups enabled students to see how other students thought, and would allow brighter students to explain how to do mathematics problems to other students. He thought he would try to incorporate cooperative learning situations in his own classroom, but was not sure how. David expressed concerns about using small groups, because he believed not all of the students would do the work.

**Category 3: Students Justify Their Answers**

David responded on the screening questionnaire that students justified their answers on a daily basis. In comparing this with the description of the daily routine in his classes, the image emerged of students justifying their answers at the board as they went over homework problems or classroom examples. David said that he would challenge the points students were making in discussions even when they were correct in order to show other students how an answer was obtained. David expressed frustration with students who would give answers, but not justify their thinking. David wanted his students to be able to justify their ideas as part of the class discussions.

**Category 4: Acceptance of Ideas**

David's teachers were open to students' ideas in mathematics class discussions in the context of solving problems after a lesson had been presented. A student having an alternative solution to a given problem was asked to give an explanation to the rest of the class. David gave the example of alternative geometry proofs suggested by himself and other students. If more than one method was used to solve a given problem, David's geometry
teacher had each student put the proof on the board and explain how he or she did it. If the class was not able to understand an alternative solution, David's teachers went back to the problem-solving method proposed for the problem.

David's own ideas about how he would behave when students began to answer problems or present their own ideas during a mathematics discussion were not well formed. He thought that in situations where students gave answers to questions, he would "try to see if they could figure out their mistakes." If the student were unable to do that, he would move on to another student. The image pictured here is of recitation, since that was the main form of interaction between student and teacher outside of lecture. David's basis for accepting ideas at this stage depended on how logical the answer was and whether the student understood it. This reflects a class in which the teacher is the main person who establishes the correctness of ideas for the class.

Category 5: Tasks that Promote Discussion

David's mathematics classes had set routines. Problems and tasks rarely diverged from fixed pattern. David could not remember seeing a problem like the one given in Scenario I in which a polynomial was raised to a polynomial in an equation, although he felt his teachers posed challenging problems to see how well students understood the material. These kinds of questions were usually given as bonus problems on tests. Problem solving in David's classes was generally a process broken into clear concise steps.

When discussing alternative modes of discussion seen in classes outside of mathematics, David talked about how his science teachers used hands-on experiences that he termed "attention getters" to stimulate discussion among
the students and introduce new topics. When asked if that approach could be utilized in mathematics classes, David responded:

In Long's [Bookstore] I saw this one thing I thought was really cool. It was an edition of thought-provoking math questions. They were just everyday problems you run into or could run into or problems about everyday life that were just kind of neat. But I could see myself using those. Using several to introduce a topic or keep [the students'] interest. Also I remember when I was a senior, it was math week, and each day the teachers introduced a new problem, trick problems, special problem, problem-solving things. I can see myself using stuff like that. Giving it to students for extra credit on homework or test problems.

David saw the potential for using problems to introduce topics and promote discussion as in science classes, although he had not experienced this approach in his mathematics classes.

Category 6: Teacher Intervention in Problem Solving

When students were struggling in solving problems, David's teachers acted in typical ways. They tended to ask questions or have students refer back to similar problems in order to gain insight into the present problem. If this failed to bring a response, the teachers started the students off by giving them the first step in the solution to the problem. As a last resort, the teacher did the problem for the students. This approach to resolving students' roadblocks established a hierarchy of teacher actions depending on the amount of difficulty the students were having in doing the problem.

David reported that he would approach his interventions with students stuck in problem solving in the same way as his teachers had. He would give hints and if they were really baffled, he would "walk them through [the problem]." In discussing how cooperative small groups might affect working with students who were having difficulties, David saw both the potential of being able to work closely with students in need of special attention, and the obstacle of becoming focused on a small number of students while the rest of
the students waited for attention. If the teacher was using the technique of
walking students through the problem, small groups would be an ineffective
setting for helping the students.

**Category 7: Orchestrating Discussions**

David's teachers had set instructional routines. Discussions were held
with the entire class seated in rows. Three basic forms of talk took place.
First, the teacher talked, giving information when a new concept was
introduced, and then examples were given to illustrate the new topic.
Second, students went to the board to explain to the rest of the class how they
solved a problem. Third, the teacher and students interacted in the context of
going over problems and examples. These interactions were either initiated
by students' questions about homework exercises or examples worked, in
class or by teacher questions posed to the students when obstacles were
encountered with a particular problem.

David pictured himself teaching in a similar manner. When asked to
describe how he would teach a lesson in a class and on a subject with which
he felt comfortable, David replied:

**David:** I would be in the front of the class with the students in
their rows, students in their chairs. I would be at the
board, introduce a topic, give an example, explain the
example, explain what I did. Give them more examples.
Let them ask questions if they didn't understand.

**Researcher:** Who would be doing most of the talking?

**David:** Probably I would, unless they had questions. I remember
asking a lot of questions as a student. I would be talking
and telling them how to do it. Answering the questions. I
think I would be doing more of the talking.

This mode of orchestrating classroom discussion is almost a verbatim
description of his own teachers lessons. It was a scenario in which David felt
he had learned effectively, and he felt comfortable in applying it in his own
teaching. In the process of being interviewed, David expressed some
discontent with the ritual of the mathematics class and how it compared
unfavorably to English classes where topics were taught using varied
methods. David was unsure of exactly how he would behave in the
classroom, but was not able to project beyond what he had experienced.

**Summary of David's Preconceptions**

David had a positive experience in learning mathematics in secondary
school. His teacher during his last three years of high school had a powerful
and positive influence on his decision to become a teacher and served as a
model of effective teaching for David, based on his success as a learner. David
repeatedly expressed he would approach discussions in the mathematics class
in a manner similar to that used by his prior teachers mainly because that was
all he knew at the time of his entry into the mathematics teacher education
program. A summary of his beliefs and projected behaviors follows.

**Flow of Ideas.** The teacher was the source of information in David's classes
and, because of his own success as a learner and a lack of alternative
experiences in mathematics, David indicated he would be the source of ideas
in his classes. Being in charge of discussions meant he knew the answers to
students' questions and could direct them to the correct answers.

**Student/Student and Teacher/Student Interactions.** Student/student
interactions were limited to those occasions when students put problems on
the board. At all other times the teacher was the central figure during
discussions, mainly presenting examples and going over problems with the
students. David pictured himself acting in the same fashion.
**Students Justify Their Answers.** Having students justify their answers was important to David in order to assess students' understanding of a concept. **Acceptance of Ideas.** David's teachers accepted alternative methods of solution after ideas had been presented to the class in lecture form, but generally redirected students back to accepted methods of solution. David would operate in a similar manner, making sure students' answers were logical in the context of the topic being presented.

**Tasks That Promote Discussion.** David acknowledged the routine nature of the lecture/recitation format of his mathematics classes, and expressed openness to the possibility of using "attention getters" to introduce concepts in a manner similar to what he had experienced in science classes.

**Teacher Intervention in Problem Solving.** David's teachers tended to ask questions, have students refer back to similar problems, or started the students off by giving them the first step in the solution to the problem when they were struggling in solving problems. As a last resort, the teacher did the problem for the students. David would approach his interventions with students stuck in problem solving in the same way as his teachers by giving hints or walking them through the problem. David was optimistically cautious about using small groups to help students solve problems.

**Orchestrating Discussions.** Talk in David's classes was clearly teacher-centered. Lecture was the mode of transmitting concepts to students, and recitation was the method by which understanding of concepts was deepened. At this stage in the development of his beliefs about teaching, David would model this type of behavior in the classroom for lack of other models.

Overall, David's prior experiences had a significant influence on his beliefs about his role in conducting discussions in the classroom. He pictured
himself as the discussion leader, which meant he did most of the talking as he introduced concepts in lectures and assessed students' understanding through going over examples and homework problems.

**Perceptions of His Role in Discussions After Participation in the Mathematics Methods Course and Related Field Experiences.**

David took an active part in the mathematics methods class and in the field experience. He took part in many of the mathematics methods course discussions, and even had an impact on the way the course was taught. David suggested it would be more beneficial to discuss rather than write about some of the articles the preservice teachers were reading for the methods class, and the methods course instructor agreed to use that format to discuss the articles.

David's field placement was in a suburban third-grade class. The class had 16 students, predominantly white. The cooperating teacher had 16 years of experience, and although not a member of the National Council of Teachers of Mathematics or particularly familiar with the *Standards*, reflected many of the ideals expressed in the *Standards*. The cooperating teacher used a system of small groups through which students rotated during the morning after full-class instruction that took place on the rug at the beginning of the day. After assigning tasks to the small groups and announcing the rotation for the morning, the cooperating teacher led the reading groups and David led the mathematics groups. In the absence of a resource person like David, the children were on their own to work together or individually in their small groups.

During the quarter, David taught only one large-group lesson, on time zones, with the entire class. The remainder of the time he was asked to prepare activities on topics chosen mutually with the cooperating teacher.
Two lessons observed during the quarter were on teaching the multiples of five in the context of telling time and on measurement.

One aspect in the summary of his preconceptions was David's role as leader in discussions. In opposition to this was David's concern about maintaining discipline in the classroom. Both the cooperating teacher and the university supervisor identified David's concern about maintaining order in the classroom and his need to be more assertive. David did not perceive himself as a strict authoritarian or a dominant figure, and acknowledged he had a difficult time keeping the children from talking. He questioned if allowing the children to talk more was his style or if he needed to take more measures to control the students. One measure he and the cooperating teacher agreed upon to help David establish his authority in the class was to put David in charge of leading the morning routine of counting lunches, taking attendance, and then leading the share session of the previous day's happenings. The cooperating teacher noted that David had made progress in this area during the time he was in her classroom.

Interactions between the cooperating teacher and David included daily discussions on various aspects of teaching in the elementary school and planning the next activity for which David would be in charge. Only one formal observation was written up, since much of the time David was occupied with small group activities while the cooperating teacher taught. The university supervisor observed David once a week and evaluated and responded to his journal entries, making comments about his observations. Although they met for lunch every Wednesday during the quarter, those interactions centered around personal happenings in David's life and not his teaching. David felt his interactions with the university supervisor helped
him primarily on a personal level. There was little interaction between the cooperating teacher and the university supervisor to identify aspects of David's teaching he needed to improve.

David seemed open to the comments of his supervisors and was willing to try their suggestions. However, when confronted with something that did not fit into his personal belief system or appeal to his own learning style, David exhibited strong opinions about the topic. The methods course instructor observed this critical side of David and identified him as the person closest to being a resistor. David exhibited this characteristic in several of his comments about teaching mathematics. His dislike for writing led him to comment that he would never utilize journals in his classroom. This was not because he thought they were impractical, but because of his own dislike for writing, a task he would not ask his students to do. Similarly, he was emphatic about not giving students homework on holidays, because that was something he felt was unfair. Coming from a large family, he wanted the students to have that time to visit without having school responsibilities.

David was sensitive to the emotional needs of his students. Long sections of his journal were devoted to describing the emotional and learning problems of several of the students in his class. David often discussed the progress of one student the cooperating teacher suspected of being learning-disabled (LD). He felt the label LD was particularly demeaning and caused parents to shelter their children from that stigma, while at the same time impeding their progress. Other journal entries mentioned students who were being considered for special schooling because of discipline problems and students who tended to make up outrageous stories to gain attention. In
spite of all this, David was considering specializing in elementary education as a result of his experiences in the third grade.

David's development in his perceptions about his role in discussions is presented in the following sections.

**Category 1: Flow of Ideas**

The methods course introduced David to new ideas about allowing students to explore ideas on their own through small group problem solving. Although David expressed that ideally, when teaching a new topic, he would like the students to discover relationships on their own, he felt he would still tend to introduce the material on his own in some form of teacher-led discussion. David began to consider alternatives for introducing ideas in the mathematics classroom, but was not able to let go of the notion that the teacher is in charge and the leader of the discussion. By being the leader, David meant doing what his teachers had done, "leading discussions, deciding what we were going to learn for the day."

David did have opportunities to see a shift could take place from a teacher-centered curriculum to a student-centered curriculum in his methods course and field experiences. First, David wrote about one incident in which he was amazed by the creativity of students in making up a play for class. He observed four children work together to create their play and described their activity and his role in the activity in his journal:

All I did was keep them on track in the ten minutes of preparation time, and they were amazing. They worked together great, brainstorming, agreeing, disagreeing, discussing, and deciding on their play.

David noted the students' creativity, but was not ready to transfer that potential into mathematics instruction at that time.
A second area in which David learned about potential methods to allow teaching to become more student-centered involved the use of LOGO. When it was discussed in the methods class, David saw that using LOGO would enable students to learn the properties of a square by having them direct the turtle to draw a square. David realized the kinds of questions he asked would change because the students would have investigated the properties themselves and formulated ideas about what those properties were.

Back-to-back groups David worked with on a series of word problems involving time illustrated his tendencies to take a teacher-centered approach in conducting discussions. With the first group, David let the students work together to solve the problems. In doing so, the students were animated in their efforts to solve the problems, discussing what they thought should be done. In the second group, David decided to lead the group through the problem together. In this situation, students waited for the teacher to direct the discussion and concentrated more on the answer, sometimes not answering David's questions. On one occasion, the following exchanges took place:

David: Eric, read number 4.
Eric: Eric's soccer game started at 4:20 p.m. It ended at 5:45 p.m. How long did Eric play?
David: This is a tough one. How do you think we should do this?
Student: One hour and twenty-five minutes.
David: He says one hour twenty-five minutes. What do you say?
Student 2: One hour twenty minutes.
Student 3: One hour, twenty-five minutes. That's what I said.

David's higher-order question of how to do the problem was responded to with an answer to the lower-order question of how long the soccer game lasted. The students focused on the answer, and not the process, a distinction David let pass.
Category 2: Student/Student and Teacher/Student Interactions

The organization of the third-grade classroom in which David did his field experience promoted the use of small groups in instruction and illustrated how a small-group setting encouraged students to communicate among themselves in doing their tasks. David recognized that when work was done in small groups, the discussions became student oriented. David acknowledged that students worked well in those settings and were able to remain on task.

David reported on an article in the methods class about the use of cooperative learning. The article provided details on group size and makeup, adaptation of tasks to the groups, and advantages and disadvantages of their use. David expressed his intentions of using small groups in instruction, but felt it would be hard to use them effectively. He recounted his own experiences as a group member and how his group would waste time talking about topics unrelated to the task given the group. David questioned how the change from the third grade to high school would affect the use of small groups. He perceived the task of the teacher while students are working in cooperative groups as being to keep the students on task.

Although David worked primarily with small groups during his field experience, his approach to teaching the groups involved more teacher/student interactions than student/student interactions. David's principal mode of interacting with students was through leading questions that directed students to the answer. He estimated that he engaged the students in questioning over 50% of his time teaching. This deviated from the lecture mode of presenting material that he experienced in secondary school and expressed a preference for in his preconceptions. David felt it
would be difficult to get totally away from the lecture mode, but imagined himself asking more questions in the "teaching" part of a lesson. David attributed this change to the influence of the methods course instructor who emphasized the use of questioning in teaching.

Several characteristics of this pattern of behavior emerged during analysis of the data about David. First, David was persistent in his use of questioning. He rarely resorted to telling the student an answer, even after several unsuccessful attempts to guide the student's thinking. One sequence of interactions between David and students trying to learn how to measure fractional distances using a ruler lasted several minutes. The student was asked to measure a segment on a worksheet and kept coming up with the solution of one and one half inches, when the actual segment measured one and one quarter inches.

Student 2: Inch and a half.
David: You think it's an inch and a half.
Student 3: Inch and a half.
David: You think it's an inch and a half. Where's your half mark on this ruler. Which line is the half mark on this ruler?
Student 2: Right there.
David: Is that what the other line goes to?
Student 2: No.
David: So what is it?
Student 2: Uhm.
David: Which one does it go to?
Student 2: That one.
David: What's that?
Student 1: The half mark. It's right here. OK. Write down what you think.
David: So what's this one then? You said an inch and a half.
Student 2: An inch and a half.
David: This is the half. What's the next biggest line.
Student 2: Uhm.
David: Try this one. The longest line in the middle was the half you said.
Student 2: Uh-huh.
David: And the next longest line, there's two of them, would be?
Student 2: The quarter.
David: Uh-huh, would be a quarter.
Student 2: So, [a pause] a half.
David: Where's the half inch? Where would an inch and a half be on your ruler?
Student 2: Right there.
David: A half is the longest line. A half is right in between.
Student 2: Oh yeah, right there.
David: Is that right in between then? Does the line fall right in between one and two?
Student 2: No. Yeah, it does, but it's not right there.
David: Where does it stop? Point with your pencil, which one does it stop at?
Student 2: Right there.
David: Right there. OK. Which mark was that? It wasn't a half was it?
Student 2: No. [Student sounded kind of sheepish at this point.]
David: What other mark was there? [no response] What number falls in between the 1 and the half? Here's your half and here's your one. What's in between those?
Student 2: A quarter.
David: So how long is the line? It goes all the way past one inch.
Student 2: So it's one inch and a quarter.
David: Right!

David persisted until the student was able to give the correct answer. The extent to which the student understood the concept is not clear, despite the correct answer given.

Second, David tried to involve all the students in the group in the conversation as he was going over the problems. His university supervisor noted that David "didn't just ask one question and get one answer and go on to the next question. He got more people involved that way." When in a small group, he often asked all the students to give their answers before trying to ascertain how solutions were obtained.

Third, David's questions were sometimes constructed to lead the students to an answer without the student understanding why the answer
made sense. For example, one student identified the three-quarters mark on the rule as one-quarter. David led the student to successfully identify the three-quarters mark by identifying the one-quarter mark, the two-quarters or one-half mark, and finishing with the question, "So, if this is one-quarter, and this is two-quarters, this is?" Although the student responded three-quarters, it was probable she was following the one, two, three pattern of the question, and not the concept of three-quarters. One interesting observation during a small group session was when one boy began to take on the role of the teacher vis-a-vis his fellow classmate. He began to ask the other student leading questions similar to David's.

Fourth, David sporadically exhibited other behaviors important in conducting discussions. Among these were restating what students had already said, not exhibiting body language as to the correctness of a response, waiting for students to respond, using questions to gain students' attention, asking students for clarification of a response, redirecting students' attention to the actual question, and modeling solutions for the students.

Category 3: Students Justify Their Ideas

As part of the interaction during questioning, students are often required to justify their ideas to the teacher and the other students. David agreed with this idea stressed in the methods class and exhibited behavior in the field experience that indicated his intention to have students justify their ideas. David often asked the students to show him how they had obtained their answer.

In the lesson on multiples of five using clocks as a manipulative, David would frequently ask the students to show him on the clock how they did the problem. After that lesson, David wrote in his journal that he would stress
that answers on paper were not important, but that understanding was. He was concerned the students were putting too much emphasis on the answer even when they didn't understand how to get it. David's preconception that students needed to justify their answers remained intact, but some of his behaviors in using leading questions seemed to be in conflict with those beliefs.

**Category 4: Acceptance of Ideas**

How ideas are received in the classroom has an impact on how students tend to participate in classroom discussions. The third-graders David worked with behaved in a manner indicating that the answer was the important objective in mathematics. Several times during David's efforts to conduct discussions, students just wanted to know the answer. Students sometimes hesitated when giving answers, because they were waiting for David to evaluate their response. Both of these behaviors illustrated students' beliefs that the teacher had the answers and would be evaluating their work.

David's cooperating teacher brought this to his attention and emphasized the importance of acknowledging students' ideas during discussion. She felt David agreed with this theory, but thought he didn't realize he sometimes said no when a student made a comment. She noted he tried to steer the student down the right avenue toward a more correct response, but saw improvement in his ability to accept students' ideas by the end of the quarter. As previously noted, David's primary behavior in leading discussions was to ask leading questions, but he would also ask students if they all agreed on certain answers. On one occasion David abandoned a worksheet with one student, and sought to build the student's conceptual understanding.
One of David's journal entries indicated he was concerned about having the right answers for the students. During his first full-class lesson he had spent several minutes trying to correct the students' mistake, only to find he had been wrong the whole time. He referred to this incident as his "idiotic blunder," noting he would henceforth have the answer available to save time and embarrassment. This incident illustrated a beginning teacher's concept that teachers are always right.

Category 5: Tasks That Promote Discussion

The most significant effect of the methods class on David's image of what happens in the mathematics classroom was in the area of task selection. Since he had experienced mostly lecture and recitation in his own learning, using manipulatives, incorporating technology, using problems to introduce concepts, and writing in mathematics class were new for David. Each had its own appeal or lack of appeal for David.

First, using manipulatives during instruction to allow students different opportunities to represent and talk about mathematical concepts had a great impact on David. He considered this to be a major revelation in terms of mathematics instruction. Their use was modeled by the professor in the methods course and by the cooperating teacher in the field experience. In the methods course, David and two other preservice teachers were given the task of planning a series of activities on volume based on a box of manipulative materials provided by the methods instructor. Similar tasks were given to other groups, and presentations of the activities were made to the entire class. In his journal, David recounted several lessons in which the cooperating teacher utilized manipulatives to teach mathematical concepts. Among the activities were using M&M's in a lesson on graphing and data interpretation,
using bean counters to illustrate multiplication, and counting the kernels of corn on a cob after estimating the number based on the number of rows of kernels and the number of kernels per row.

David attempted to bring manipulatives into the activities he planned for the field experience. In both the observations made, David used manipulatives of some sort. In a lesson integrating telling time with the multiples of five, all the students were given replicas of a clock to enable them to make the connection between each number on the clock representing an interval of five minutes. In a second lesson, students used rulers to measure lengths on a map as they calculated actual distances based on the map's scale. In addition, David used manipulatives spontaneously to illustrate mathematical concepts. On one occasion, students were not understanding the concept of one-half, and David used two checkers to demonstrate the concept. He wrote in his journal:

I used checkers to show them that if two halves equal one whole, and each checker is one half, then if they pair the checkers into sets of two, the full number of sets is equal to a whole number, with any lone checker left over still equal to one half. Amazingly enough, they got it! David seemed surprised his idea worked. The event made an impression on him, because he recounted the event to his peers in the methods course and referred to it often.

David acknowledged the effect of manipulative use on discussions in the classroom. He felt he would ask more questions involving the manipulatives, and that the teacher lets what the students try "to understand from the manipulatives, instead of just telling them." David saw that manipulatives would affect the vocabulary used to develop a concept. If cups of beans were being used in place value, instead of talking about "carrying,"
the teacher would talk about transferring the beans from one cup to another.

Another effect manipulatives had on discussion was that students were asked to show how they obtained answers using manipulatives. When working on the lesson with the clocks, David frequently asked the students to use the clock to solve problems and justify their answers. He also modeled problem solving with the manipulative.

Despite his efforts to incorporate manipulatives in the classroom, David expressed difficulty in imagining how to plan lessons involving manipulative use. In discussing his teaching, he replied:

There are still some things that we were told we should do, that are good ideas to do, in the methods course instructor's class, that I know I'm not doing. It's hard for me to incorporate manipulatives. I know I do, I do it more spontaneously than planned for some things. Of course a lot of things that I taught this quarter were, they weren't real math concepts. All I ever dealt with were like side items, time, distance, measuring, which I think are cool and important, but they're not addition, subtraction, the main things our grade was learning. So, I didn't use a lot of manipulatives in math, not like the methods course instructor taught us this quarter.

David was tentative in stating how manipulatives changed discussion. He stated:

I guess you would start discussions differently if you used cuisenaire rods or something. The kids start playing. Start asking questions that way about it. I don't know how else it could affect it.

Overall, the introduction of manipulatives in instruction made a great impression on David, but their impact on class discussions was not completely clear in the early stages of his development.

Second, calculator and computer use in mathematics instruction were stressed by the methods course instructor to the extent that David wrote in one paper that a teacher's failure to use graphing calculators to teach calculus was "punishable by death." David was impressed by algebra problem-solving
computer software that helped students develop heuristics instead of merely leading them to an answer. David had never used a graphing calculator before the methods class and was impressed by several of its features. One demonstration in class showed how the simultaneous graphing of parametric equations representing a motion problem could simulate the time two trains would cross. David was introduced to LOGO in the methods course and appreciated the possibility of utilizing the software to teach students concepts like square in a way that allows students to explore what a square is instead of being told what it is.

When asked how the use of computers and calculators in instruction would affect discussions, David's response indicated he had not formulated in-depth thoughts concerning the connections between technology and discussion. This is not surprising since he had not utilized either during his field experience. David perceived computers as a tool to augment teaching with which students could work individually. He didn't know how it could be integrated into a whole classroom discussion. David felt graphing calculators would help generate discussion because students could look at graphs and learn by examining its characteristics.

While manipulatives and technology appealed to David, other tasks did not have any particular impact on David's approach to teaching and conducting discussions. Writing journals was a task David would not ask his students to do, despite the fact that he acknowledged its potential benefits. David preferred to discuss issues rather than write about them. Problem solving was another task emphasized by the methods instructor that David incorporated into his own teaching, but he was not particularly sure why so many problems had been done during the methods class. This lack of clarity
as to the purpose of those activities supports the methods course instructor's comment that she was unsure of the extent to which the preservice teachers would apply modeled behaviors in their own teaching. David did, however, utilize word problems in many of his lessons, usually employing the technique of personalizing the problems to stimulate students' interest.

**Category 6: Teacher Intervention in Problem Solving**

David had ample opportunity to develop his ideas about how he intervened when students experienced difficulties in problem solving or understanding concepts. Because the cooperating teacher was occupied with reading groups as the students worked in small groups, students' questions were addressed later by the cooperating teacher or by resource people like David during class. Several aspects of David's perception of his role emerged as a result of his comments and behaviors.

First, David exhibited behaviors he identified as typical of his own teachers in problem-solving situations. One behavior was to refer the student back to prior knowledge. If a student was stuck at a particular point, David would point out a similar problem the student had already done and imply that the student should apply the same idea to the current problem. In a similar way, David restated ideas a student had already expressed and then built further discussion around those ideas.

Second, as already stated, David often asked a series of leading questions to overcome obstacles. Depending on the responses of the student, the questions either progressed to more difficult ones or became simpler to reach the level of understanding of the student. An example of this is the following excerpt of a lesson in which David was trying to help a student understand the meaning of the marks on the face of a clock.
You said this was 9:09. You've been counting by 1. You were doing well, Bill. If this is 9:09, and you added 1 on, what time is it to come? [No response.] If you add 1 on to 9, what is that? [No response.] 9 plus 1 is?

David's questions went from asking for the time, to asking a simple addition problem, to simply stating "9 plus 1 is?" - a fill in the blank question.

On one occasion, after experiencing some frustration with the same student mentioned above, who did not respond well to the questions David was asking, David wrote about the experience in his journal. His university supervisor commented about the possibility of having the student explain how he figured out the answer to a simpler problem in order to shed light on his thinking for the problem with which he was having difficulty. This comment was made early in the quarter, but David's behavior did not change over the course of the quarter.

Third, an interesting situation involving mathematical notation was identified in the analysis of the observations. Students used loose language in representing fractional markings on a ruler. For example, the answer to one question was four and one-half. In discussing the markings on the ruler, the students utilized the term one-half, but when one student was confused about how to write the answer, another student said to write "four and one slash two." The student who did not understand the original problem wrote down the answer, but in a way that expressed forty-one halves. Adapting his language to the level of the student, David began to use similar terminology to help the student write the answer, but in doing so, helped ingrain faulty language in the student's mathematical vocabulary.

To a lesser extent, David exhibited other behaviors with respect to helping students during problem solving. Among these were giving hints to students who were working on their own, giving more examples to help
students understand concepts, focusing his attention exclusively on one student while other students worked independently, and working with extreme patience before giving a student an answer. David wrote of leaving a class with fingernail marks on his hand from the stress produced in working with a student who could not understand the concepts involved in a simple word problem.

**Category 7: Orchestrating Discussions**

With respect to deciding on who talks and when, several factors determined David's behavior. David continued to see himself as the leader in this realm. He initiated discussion and determined how to keep a discussion on track. David's lessons started off with some form of assessment of the students' knowledge. David's experiences in college lectures made eliminated pure lecturing as an option for him, although he expressed the belief that he would use lecturing if it meant students would understand the concepts. Students were encouraged to participate in discussions without restraint. David did not require students to raise their hands in discussions, fearing that would discourage them from participating. This reflected his own experience of not liking having to raise his hand in classroom discussions. When asked about who he would like to do most of the talking in his class, David wanted more student input. However, when asked what his ideal lesson on fractions would be like, David said he would be doing most of the talking. This contradiction did not escape his attention.

David's cooperating teacher modeled teaching methods in which the lecture was not the major form of conducting classroom discussions. David noticed this his first day in the cooperating teacher's classroom when he noticed all the chalkboards were covered with displays. Instead of
chalkboards, the cooperating teacher utilized portable white boards during full-class discussions. However, David did not have many opportunities to discuss the cooperating teacher's methods with her; most of their interactions were limited to problems involving specific students.

The cooperating teacher indicated David was more comfortable in the small groups than in front of the entire class. He had a hard time thinking about the many things to keep in mind when working with students at this level. The cooperating teacher attributed this to the fact that students at this level adapted more easily to small group activities, an idea David found difficult to deal with when he first entered the class, but came to appreciate over the course of the quarter.

A final aspect of David's decisions in orchestrating discussions involved his ability to listen to students' responses and adjust the questions he asked accordingly. Good listening was identified by the methods course instructor as an important aspect in class discussions, and the cooperating teacher assessed David as a good listener. She said:

He responds to what the kids are saying. He's not so caught up in what the has to tell them that he doesn't hear what they are contributing or asking.

David was able to adjust his lessons to the level of the students. One adjustment he made in his lesson on multiples of five was to begin to go over all the problems as a group instead of having students work on the problems individually or in pairs. This produced a microcosm of how David would teach a large group, but only with a handful of students. In that situation, David entered the teacher/student questioning mode that was the principal form of interaction with students.
Summary of David's Beliefs and Behaviors After the First Quarter

The experiences David had during the first quarter in the mathematics methods class and the field placement in the third grade challenged many of David's preconceptions about teaching. The most influential of these were the new ideas originating from the methods class. David had never been exposed to the use of manipulatives or technology in mathematics instruction in his own learning, making the introduction of their use into his own teaching a challenge. David developed some patterns of interaction with the students during the field experience that reflected his high school teacher in certain respects. The summary of these finding is reported in the different categories.

Flow of Ideas. Exposure to the Standards, in which emphasis is put on having students explore concepts on their own, made David rethink his belief about always introducing the topic to the class first. Although he expressed that in an ideal situation he would want his students to discover, he would still introduce the topic in some way first. Technology like LOGO and actual experiences with creative students who exhibited discovery behaviors influenced this change.

Student/Student and Teacher/Student Interactions. The use of small groups in the field experience and in the methods class helped David see how they promoted greater student/student interaction. However, David's approach to discussion reflected a teacher-centered approach in which all the questions originated with the teacher with the intention of leading them to the answer. This was David's principal form of interaction with the students.

Students Justify Their Ideas. David's preconception that it was more important for students to understand a concept than just produce an answer
was reinforced by the methods class instructor who emphasized the "why" question. David naturally incorporated this into his questioning methods. **Acceptance of Ideas.** In spite of David's professed desire for students to justify their responses, the cooperating teacher brought to David's attention that he sometimes would respond to students' answers with a "no." David improved in this behavior by the end of the quarter, but David continued to have the idea that the teacher needed to lead students to the right answers. **Tasks That Promote Discussion.** The most significant changes took place in David's beliefs in this area for the simple reason that he was introduced to many new approaches to teaching that differed from his learning experience. David was exposed to manipulatives in the methods class and in the field experience, and incorporated them in his teaching. Although he acknowledged how their use changed the questions a teacher asked, he had difficulty seeing exactly how he would incorporate them in his lessons. David accepted the use of technology in changing the class discussions, but did not experience that in the field. **Teacher Intervention in Problem Solving.** David's behaviors intervening with students stuck on problems reflected his preconceptions. His tendency was to lead students to the answer through a series of leading questions that built on what students already knew. Obstacles arising from poorly understood use of mathematical symbols involving fractions went overlooked by David. **Orchestrating Discussions.** David's principal mode of engaging students in discussion was through leading questions rather than direct transmission of facts through lecturing. This diverted from his original intention to model his former teacher who normally introduced new material via lecture. David
displayed skills of listening to students' responses in order to adapt questions to the students' levels.

Overall, David embraced the new ideas promoted in the methods class with an open mind, but was not able to accept all of them into his own belief system. He accepted the idea of engaging the students in more discovery activities, but persisted in teaching in a manner leading students to correct answers. He intended to use manipulatives and technology, but had not yet experienced the techniques enough to guarantee success in using them. He rejected the use of techniques such as student writing, because it did not fit into his learning experience. In sum, David was excited about the new ideas he had experienced the first quarter, but still held on to many of the beliefs with which he entered the program.

**Perceptions of His Role in Discussions After Participation in the General Methods Course and the Mathematics Education Field Experiences.**

David was placed in a sixth-grade class in an urban middle school in the same city as his university. The majority of the students were African American. The cooperating teacher taught both mathematics and science to the same groups of students in back-to-back classes. She had taught 20 years and had supervised about 6 student teachers prior to working with David. Although not a member of NCTM, she had recently participated in a joint university/school project to promote inquiry as a mode of learning in mathematics and science.

The physical classroom was arranged in tables to accommodate small group instruction. A computer was available in the back of the room mainly for enrichment activities. David noted a lack of decoration on the bulletin boards in one of his journal entries, a surprising observation since he had
commented to his general methods instructor about his personal disinterest in them.

David was initially uneasy about coming into an urban school and working with African American students, a minority group with which he had had little contact. He was relieved when the children were excited about his arrival, and concluded that these children were no different from others with whom he had previously worked. The students were interested in what he was teaching, a fact verified by students' comments recorded during teaching sessions.

David would normally observe the cooperating teacher teach the first mathematics class and the subsequent science class to the first group of students and then teach the mathematics class to the second group of students. The benefits of these experiences were minimized primarily by three factors. First, David left each day at 11:00 and was not able to remain at the school to process what he had experienced or observed with the cooperating teacher, since she was in the middle of teaching the second science lesson at that time. Although he was open to suggestions, David's expressed learning preference was for someone to tell him what to do. Without clear direction from the cooperating teacher, David had to come up with ideas on his own, something he found difficult. This situation affected David's preparation habits for the lessons he planned. David was often given the topic to teach upon arrival at the school and had to prepare only minutes before teaching the lesson. This prohibited David from preparing the type of lessons he envisioned trying in the field experience. When asked how the field experiences had changed his teaching, he responded:

I picked up the bad habit of just going in unprepared for the day. I would do this every Thursday. I would just go in, I would get there at ten to
eight. I found out what they were doing and I said this is easy for me to get them to go over.

David's lack of preparation caused him to rely on old patterns of behavior, making his teaching more teacher-centered, usually based on material directly out of the textbook.

Second, the cooperating teacher spoke of teaching approaches that modeled the methods instruction David received the previous quarter, but her behavior in class did not model her expressed philosophy. David did not observe any hands-on science or mathematics activities while in the classroom. The cooperating teacher revealed in an interview that she had reserved those activities for Tuesday and Wednesday, when more students would be present, and so that she could give more time to mathematics on Thursday and Friday.

Third, although the university supervisor provided feedback to David about his lessons, it mainly consisted of suggestions related to short-term changes. David received feedback after each lesson, but did not receive a final evaluation or make a plan of action for subsequent development. Little communication existed between the cooperating teacher and the university with respect to learning objectives for the experience outside of the classroom syllabus that explained the requirements each student was to fulfill during the quarter. As a result, David was unable to address questions he had about classroom management, the use of manipulatives, and the use of technology.

In commenting about his view of the Standards, David said:

The question that I always raised. Over and over again in the Standards, they stress manipulatives, they stress using calculators, they stress all these good strategies. It's the same thing with me applying them in the classroom. How do I apply them? I don't know how to do that yet. I know I need to do these things, how do I do them. Tell me how to do them. Stop telling me I need to do them, because I know already I need
to do them, and why I need to do them, and I see they are beneficial. How do I do them? Show me, show me. That is one thing that I kept thinking throughout reading the Standards. This works well on the vignette you give me, how do I apply it generally? How do I remember it?

David's mathematics field experience left many questions unanswered.

The most constructive feedback was given to David in a chance observation by a doctoral student working with the cooperating teacher. Observing David's lesson on measurement, the doctoral student made 16 observations about the lesson, many of which pertained to the discussions that took place during the class. The observations were concise and reflected a teaching philosophy consistent with the methods instruction David had received. Because this was a one-shot happening and no provision was made for follow-up, the comments went largely unaddressed.

David was the catalyst for having the writing assignment on the Standards transformed into a bi-weekly seminar during the second quarter. He led the discussion during the first meeting and was an active participant in subsequent meetings. His concern about how to do things was reflected in the questions he raised and concerns he expressed about what he saw in the classroom.

The general methods course had little direct impact on David's classroom behavior. He perceived the course as being geared toward elementary education majors, and David felt it would be unlikely for him to plan a lesson or make a classroom decision based on educational theories he learned in the course. His field experience at the secondary school was limited to two days, minimizing the impact it had on his thinking about teaching. Despite David's attitude toward the course, he utilized many of the
concepts introduced in the course in the final interview and surprised himself at how much background information the course had provided.

The remainder of the data analysis for the second quarter is reported in the pre-established categories.

**Category 1: Flow of Ideas**

The field experience in the second quarter allowed David to teach several lessons. David's expressed belief to be the "leader" was reflected in his method of introducing ideas in the classroom. Despite the expressed desire to have ideas originate with the students, David's behavior modeled his high school teacher's approach to discussion more than the student-directed discussions held by his methods instructor, and he felt it was still the most effective teaching model for him. In his last lesson observed by the university supervisor on addition of fractions, David had brought in fractions bars to help develop the concept, but decided instead to present the concept at the chalkboard, introducing the idea to the students and making sure the students understood the need for a common denominator. The teaching sequence in which the teacher introduces the material, the class goes over examples, and students do problems at their desks had not changed from David's preconceptions. David found it difficult to picture *Standards*-like lessons in which students initiated discussion, since those types of lessons were not modeled in his field experiences.

Another reason for the maintenance of this behavior may have been the lack of preparation time for his lessons. When preparing a lesson upon arriving at the school, or developing a lesson plan during the science period before the second mathematics class, David relied on what was familiar to
him, the methods he had seen practiced all throughout secondary school. In David's journal, he voiced that idea:

When third period rolled around, the cooperating teacher asked if I would like to go over some of the story problems with this class. Even though I had no preparation except watching and listening first period, I knew I could get the kids to do the story problems successfully. His task was to lead the students to do the steps necessary to find answers.

David expressed the predisposition of "getting the kids to do" the problems successfully. This procedural approach to mathematics was reflected in David's methods of conducting discussions. In describing his lessons, David utilized language that indicated he perceived his task as being to convince the students of certain ideas he had predetermined. He said he "stressed the fact OVER and OVER," he knew he could "get the students to do" problems, and he "made them notice" patterns in problems. This, however, was done without giving students answers, a practice required by the university supervisor and unilaterally agreed upon by the preservice teachers in their seminars.

Other behaviors David exhibited indicated he was not completely closed to students' ideas in the classroom. First, he preferred discussions to be "free-flowing." He wanted students to feel free to share ideas without being constrained by classroom protocols. This approach reflected prior beliefs and was reinforced by the geometry teacher with whom David had his secondary field experience in the general methods class. Second, David was aware of and practiced wait time. He commented on how his cooperating teacher frequently did not wait for students' responses, something he would do in deference to different students' learning abilities, not necessarily as a tactic to facilitate student input into discussions. Third, David usually asked for
students' understanding of new vocabulary words before moving to a formal definition. Fourth, David assigned a student's name to the rule she had proposed in a lesson on addition of fractions. By personalizing the rule, David assigned importance to the student's idea.

Category 2: Student/Student and Teacher/Student Interactions

The principal mode of classroom interactions in David's classes during the second quarter continued to be teacher-dominated questioning. This mode of interaction was encouraged by the cooperating teacher and university supervisor. However, the balance between it and questions to promote the higher-level thinking desired by the methods instructor was never attained. David's questions tended to be more factual or leading, a mode of questioning that placed a high premium on the answer, although the cooperating teacher reported that David had made progress in asking higher-order questions.

A significant teaching event illustrated this point. An activity to review equivalent fractions was given to the students. Points around a square were labeled with fractions, and the students' task was to draw line segments between equivalent fractions. David decided to do a couple of examples before allowing the students to work on their own. He used the first example to illustrate the method of multiplying numerator and denominator by the same number, starting with 2, until an equivalent fraction was found. The second example proved to be problematic. The suggested method of multiplying did not produce an equivalent fraction. Having taken the activity from the textbook, David was unprepared for that result, and now began asking the class what else they could do. One student suggested they "go down." That suggestion led to the following exchange:
David: What did you say Andrew?
Andrew: Go down.
David: Go down. How would you go down?
Andrew: Subtract.
David: Well, if we multiplied to go up?
Students: Divide.
David: Divide! What can we divide these both by?
Student: Three.
Student 2: Two.
David: We divide top and bottom by three. Can we use 2? Who said 2?
Student: No.
David: Can we divide by 2, Kyle? Is 9 divisible by 2?
Student: No.
David: So let's try dividing by 3. Is that one up there?
Students: No.
David: It better be.
Students: No.
David: [Laughs.] I didn't think I did?
Researcher: There's one up there, David.
David: [Laughs.] He says it's up there.
Student: 1/4.
David: Is 3/4 equivalent to 1/4?
Student: Three over two.
David: How else can we reduce nine-twelfths?
Student: Three-sixths.
David: Mmmm. Well. Suggestions. Anyone? No we can't give up.
David: We got that 9/12 is equivalent to 3/4. Can we reduce this anymore?
Student: No.
David: We know this is equivalent to this. Is this equivalent to anything else? If we just ignored this, how would we find a fraction equivalent to that?
Student: Multiply by 2.
David: And what do we get?
Student: 6/8. And that's up there.
Student 2: Oh that's cool.
David: That was a tough one. That was tricky. What do you think might be easier to start with when you're doing this? Pick big or pick little?
David stumbled into a problem-solving situation. Instead of allowing the students to explore the suggestion to "go down," he chose to lead them to the answer through a series of questions. Even at the end of the sequence, David suggested a strategy for choosing the initial number, rather than letting the children explore a strategy of their own.

David sometimes utilized questioning for purposes other than assessing students' understanding. First, if he noticed students who were not involved in the class, he asked them a question to draw them into the discussion. Second, as a means of discipline, David directed questions toward students who were disrupting the class. Third, David asked students to do problems on the board, if he felt they did not know what they were doing, as a means of making the point that they hadn't understood the material.

Student/student interaction occurred mainly in small groups when David decided to utilize cooperative learning. The mathematics methods class instruction frequently modeled this format in the previous quarter, and the general methods instructor continued to model the format during the second quarter. The classroom set-up of having students seated at tables encouraged small group activities. In two of the classes observed, David had some form of small group activity, and in the activity he deemed most successful during the quarter David had teams of students measure objects around the room. During this activity the observing doctoral student commented that David needed to have children respond so that the other students could hear in order to stress that the students are responding to each other and not just the teacher.

Despite these advantages, David's interactions with individual groups normally reverted back to a questioning session with David in charge of
leading the students to the solution. When he visited one group stuck on a problem, the focus became teacher-centered and communications between students was shut down. Student/student communication suffers when the objective is obtaining a solution and not sharing thinking about a topic or problem.

Category 3: Justifying Student Responses

Asking the "why" question was ingrained in the students during the mathematics methods instruction. David fully accepted the idea that students should justify their ideas. However, the use of such questions and the conditions under which they were asked were not always consistent with the intent of the mathematics methods instruction. Often when David asked students why they did something, it was to elicit the rule used to perform the procedure. Using the "why" question in this manner created another form of recitation not an opening into the students' thinking about mathematical concepts.

For example, while working with equivalent fractions, a student was asked why two-fifths was equivalent to eight-twentieths. The student replied, "Because 4 times 2 is 8 and 4 times 5 is 10," to which David replied, "Good." This response had allowed David to find out what the student had done without finding out the student's real understanding of equivalent fractions, a fact David overlooked. Many times when David asked students to justify their answers to procedural questions, their response could only be, "Because." In the same teaching sequence, David asked for fractions equivalent to four-fifths. A student replied 24 over 30. David asked the student why the fraction was equivalent, but before the student was able to respond, David continued speaking, asking by what number he had
multiplied. Asking for justification in these circumstances was more fact oriented than thinking oriented, with the latter being the desired reason for asking for justification.

In contrast to the times David asked for justification were the opportunities in which David failed to ask for justification. Three of the doctoral student's observations of David's lesson noted this fact. First, the doctoral student urged David to seize the moment and ask students to defend themselves when they loudly call out answers. Second, a student had made an error that the doctoral student wanted David to challenge. Third, David had asked a student to verify what someone else had said, but the doctoral student wanted David to open up the idea to the class by asking who agreed or disagreed with the answer. Each of these comments encourages teacher behavior that challenges students to defend their thinking, not only their answer.

These comments were largely left unaddressed because of the brief nature of the interaction between David and the doctoral student, and because they were not developed by the university supervisor or the cooperating teacher. David commented on several occasions that the cooperating teacher hardly ever asked students to justify their answers. Without having the behavior modeled and subsequently processed, David was left thinking he was asking for justification, when in fact his questioning often fell short of eliciting student thinking, in spite of having asked "why."

Preparing students to defend their thinking was another obstacle David faced in having students justify their thinking. David recounted the progress he saw in how students developed their ability to justify their responses.

I know this quarter every step a student would do, I would ask them why. At the beginning of the quarter that was really hard because they
didn't know why or if they did they couldn't verbalize it. A lot of the skills they learned were just memorization. They had no concept behind them. When I started asking "why" they really don't know why you do it. But by the end of the quarter when I was asking them why they knew I expected an answer and they got bolder in their answers and would sometimes give me an answer.

Having students who were not accustomed to justifying their answers in class masked the lack of depth of the questions David was asking. Even so, just having David ask the questions forced the students to begin thinking along those lines.

**Category 4: Acceptance of Ideas**

The manner in which David responded to ideas advanced by the students was consistent with his belief about being the "leader" of discussions and his use of leading questions to direct students to the correct answers. David accepted students' ideas, but normally redirected the discussion toward the principle he was looking to establish.

This behavior was exemplified in David's lesson on equivalent fractions. He wanted to establish the procedure to find equivalent fractions by multiplying numerator and denominator by the same number. Three problems from the text asked the students to complete the next three fractions in a series of three equivalent fractions. In going over the problems, as each student correctly provided the next three fractions, David asked how they obtained the answer. In each case the students said by applying the addition pattern in the numerators and the denominators. The following exchange illustrates David's response in each case.

**David:** And that's why we can do that. Right. We are multiplying by one. Let's see if we can do some of these, find patterns like we were doing yesterday. In this pattern. This is an easy one. You
guys fill in the next three equivalent fractions in this pattern.
Hold on. Raise your hand. What do you think, James?

James: 4 over 20.
David: 4 over 20.
James: 5 over 25, and 6 over 30.
David: What's this one. 6 over 30. How did you get that James?
James: I looked at my pattern on the top and the numbers on the
bottom go up by 5.
David: You were looking at the addition pattern, sort of. You were
increasing this by 1 and this by 5. Is there any multiplication
pattern that you see on this? Like we were just doing? We
were multiplying.
James: Yeah.
David: What do you see. Like for this one. What did you multiply
by?

David had just explained how equivalent fractions were obtained by
multiplication and the student decided to utilize the addition pattern in the
series of fractions. David's responded by accepting the addition pattern, but
redirected the student's attention to the multiplication pattern by asking for
the multiplication pattern in the series. For each of the other two series the
students responded in the same way, as did David. When the student
identified the multiplication solution, David responded with an enthusiastic,
"Right!"

During the interview after the second quarter, David listened to this
segment of the lesson and was asked to evaluate his strengths in the teaching
episode. He responded:

I made them notice patterns, which is something that was stressed. They
noticed an addition pattern and that wasn't the point I was getting at. I
didn't say "no that isn't right" because it was right, but I wanted them to
see the multiplication pattern there. So I asked for that pattern along
with it.
David saw this behavior as a strength indicating a strong belief in this pattern of conducting discussions. Students' ideas were important to accept, but the main goal was the predetermined teaching objective.

This behavior pattern was not noticed by the university supervisor and the cooperating teacher, thus reinforcing the behavior. The observation by the doctoral student did direct David's attention toward exploiting students' ideas and changing the focus for acceptance of ideas away from the teacher and more toward the class community. The doctoral student commented:

Try to get the authority for correctness of responses to be the group consensus. You would like to establish a "taken-as-shared" approach. Suggesting a "taken-as-shared" approach, the doctoral student wanted David to move away from being the authority in establishing correctness. He challenged David to think of alternative behaviors by raising the following question:

What if the "taken-as-shared" meaning does not correspond to the generally accepted meaning? What can (should) the teacher do about that?

Subsequent lessons did not indicate that David had fully processed those comments.

David was aware of and utilized some alternatives for these kinds of situations. He wanted students to challenge the teacher's answers. In a lesson taught by the cooperating teacher, David encouraged the students to challenge her when she had made a mistake in calculations. After the comments by the doctoral student about asking for agreement from other students when an answer was given, David asked other students what they thought before redirecting the discussion. The use of counterexamples to challenge or extend students' thinking was brought up in the methods course
seminars, but this was an idea with which David was not familiar. He had to ask what counterexamples were when they were discussed.

**Category 5: Tasks to Promote Discussion**

This category constituted an area in which David's perceptions of conducting discussions changed the most. Although the learning theories taught in the general methods class reinforced the use of manipulatives, little in the field experiences affected David's perceptions in this area. However, the field experience of the second quarter offered David the opportunity to implement many of the new ideas he had learned. Task selection to promote discussion involved three major areas: the use of manipulatives, problem solving, and technology.

David continued to express the need for direction on how to use manipulatives as he concluded the first quarter. Although his cooperating teacher considered herself to be a hands-on teacher and expressed the desire to utilize manipulatives, David rarely observed lessons involving manipulatives from which he could gain insight into their use. David relied on his own best judgment to implement their use.

In the three lessons observed, David did not utilize manipulatives, even though one was on equivalent fractions. His journal entries on other lessons and his supervisors recounted David's attempts to bring manipulatives into the lesson. His favorite lessons of the quarter were a series of hands-on lessons on the metric system. After finding the school library's supply of manipulatives in disarray, David borrowed manipulatives from his university's media center to conduct the lesson. David used an eyedropper to fill a 2-liter Coke bottle to illustrate the concept of milliliter. He expressed
surprise when he felt the students had learned the concept and were able to apply it.

David's other attempts with manipulatives were less successful. In his lesson on the addition of fractions, the cooperating teacher didn't have appropriate manipulatives, so David cut up some pieces of paper to illustrate one-fourth plus one-third. He tried to illustrate the concept to the students in the first period, but abandoned that approach in the second period after feeling like it was unsuccessful. In an impromptu lesson on elapsed time, David regretted not having clocks like those he had used in his third-grade class to give the students help in solving the problems. However, David persisted to successfully utilize checkers to illustrate decimals and division, a practice he had developed in his last field experience.

David lamented the lack of training he had received about how to use manipulatives. When asked at the end of the quarter how he would prepare for a lesson on equivalent fractions, he was unsure if he could integrate manipulatives into the lesson, even if he had sufficient preparation time, a commodity he lacked in the field experience. This echoes the sentiments of the methods instructor, who was disappointed in the discrepancy between what she had perceived as acceptance of manipulatives and their lack of use in the classroom. This discrepancy was often due to the lack of support given to manipulative use by the cooperating teachers as reported by preservice teachers who had prepared lessons with manipulatives, only to be given worksheets to do when arriving at the school.

Several perspectives on David's approach to problem solving emerged from the data. First, David stressed the steps used to solve certain problems. He had the students identify steps to solve word problems involving
measures given in different units. The steps the students identified seemed to have been seen by the students before, although David felt the students had come up with themselves. Second, David felt problems could be used as attention getters, drawing the students into discussion about a topic. Third, David expressed the desire to use problems as enrichment activities for his class. Fourth, David preferred to give students "real-life" problems, and often personalized problems by inserting students' names, a practice he carried over from the first quarter and reinforced during the mathematics methods seminars.

The field experiences did not foster David's development in utilizing problem solving as a transition into concept formation. Problem solving usually followed instruction on a topic. In addition, the cooperating teacher opened one of her lessons on word problems during the first period with an explanation of how much she hated story problems when she was in school and how hard she knew they would be. In reaction to that, David opened the third period with a problem he introduced verbally, and congratulated the class after successfully solving the problem, commenting they had just done a story problem. Another behavior David developed during the field experience was his reliance on the textbook. Because he often prepared at the school, assigning homework from the textbook was easy, an aspect of his field experience David did not like. Even though he expressed his disdain for this practice early in the quarter, he was not able to break the pattern of behavior.

Calculators were the main form of technology utilized during the quarter. David used them primarily as a computation tool, but saw that calculators could be used to have students check for the reasonableness of their answers. In reviewing another segment of his lesson on solving
problems involving decimals, David identified not having used calculators as a weakness in the lesson. Other technology in the classroom included a computer primarily used for recreation during extended homerooms. David did not feel the computer software available was very beneficial to learning mathematics concepts.

**Category 6: Teacher Intervention in Problem Solving**

David's approach to helping students who encountered obstacles during problem solving did not significantly change during the second quarter. He continued to exhibit three particular behaviors identified in the first quarter. First, when students got stuck during classroom discussions, David asked leading questions to direct students toward the correct solution.

Second, David sometimes gave students hints to redirect their thinking. Hints took several forms. Sometimes students were told directly that the information given was a hint. For example, when trying to find an equivalent fraction, David told the student the solution had something to do with the pattern seen in the previous problem. David gave a student a hint by emphasizing the word "times" when trying to help the student see that multiplication was the correct operation to perform at that stage of the problem. If the problem required the application of a procedure, David reiterated the steps identified in the procedure.

Third, David tried to break down the problem into simpler parts. In his problem-solving lesson early in the quarter, the students became stuck on trying to find the tip for a bill of $21.35 if you gave the waiter 25 cents for every dollar of the bill. The students were able to calculate the tip for the dollar part of the bill, but got hung up on the 35 cents. Despite efforts to break the problem up, the students were not able to make the connection that if
they could multiply the dollar part by 0.25 to get that part of the tip, they could multiply the 35 cents by 0.25 as well.

One aspect of intervening in problem solving that continued to give David problems was his tendency to focus on one individual to the exclusion of the rest of the class. This occurred both during full class discussions and when the students were in small groups. The university supervisor had pointed this out to David in observations of his lessons, particularly in the large class discussions. David identified this as a weakness after listening to his lesson on problem solving. He commented:

That's one. Going over the problems. Sometimes I'll get stuck with one group. Not really stuck, but I'll start paying attention to one group and working on a problem, and I ignore the other groups. I remember this. I do remember going around to all the other groups a lot.

David had done this during the first quarter, but was able to pick it out himself in analyzing his behavior, an indication of growth in this area.

**Category 7: Orchestrating Discussions**

David's principal mode of operation exhibited during the first quarter, orchestrating discussions by asking leading questions, did not significantly change over the course of the second quarter, despite his participation in the general methods course, the seminar with the other preservice teachers, and contact with the cooperating teacher and university supervisor out in the field. Each contact provided different experiences that may have caused change, but changes were not recorded in David's expressed beliefs and behaviors by the end of the quarter.

The general methods class modeled a student-centered classroom discussion. Discussions predominantly revolved around small-group learning activities in a manner consistent with the changes being
recommended by the *Standards*. The general methods instructor commented that the mathematics education majors frequently talked about the changes being proposed in mathematics education, and felt the methods modeled in the course were consistent with those changes.

The seminar was an open forum led by one of the preservice teachers in which topics arising out of the field experience related to the *Standards* were discussed. The original intent was to focus on the *Teaching Standards*, but the agenda shifted to related experiences instead. The methods instructor felt the students experienced learning through discussion during these meetings, which provided them with an alternative to lecturing, but was not convinced these experiences would transfer into the classroom.

The inability to transfer such experiences from the college classroom to the secondary school classroom was heightened by not having a cooperating teacher whose behavior during discussion moved away from the lecture format and more toward a student-centered classroom. David's view of the cooperating teacher at the end of the quarter was that of a lecturer. He said she conducted discussions:

 Pretty much just as a lecturer. Telling them how to do things. I don't want to say she never asked them why, but it was not something that she did often. She said she used a lot of hands-on [materials] in discussions and she never did. I never once witnessed her using manipulatives in her classroom. I asked her one day for something just to help with fractions, the day I was adding fractions, and she had nothing that would help us with that.

The lack of a model in the mathematics classroom made it difficult for David to transfer what he had seen in his college classes to his sixth-grade class.

David's beliefs about his role in classroom discussions are reflected in his behaviors. Concepts were usually developed in two stages in David's classes. First, the introduction stage usually consisted of David presenting material to
students with him explaining the material and doing 70-80% of the talking. This explaining period was not straight lecture, but interspersed with questioning of the students.

An example of this was seen when David wanted to bring out the fact that in the case of fractions, multiplying does not always make the number bigger. This concept was being brought out in the context of a problem in a section on metric conversions. After identifying that the students needed to multiply by 0.05 in order to solve the problem, David engaged the students in the following discussion:

David: This eye, the human eye is point oh five times as big as the squid's eye. But, she just said that we should times this. Don't we get a bigger answer if we times two things together?
Student: Usually.
David: Usually. Can't you see that our human eye is going to be smaller than this? Why? Why when we multiply this by that are we going to get a smaller answer this time? Instead of a bigger answer. When usually when we multiply we get-
Student: Bigger answers.
David: Bigger answers. What do you think? What's kind of strange about this number. What happens when you multiply 1 by 38?
Student: 38.
David: 38. Look at this number. Is it bigger than 1 or less than 1?
Students: Less.
David: Less than 1. When we multiply a number that is less than 1 by another number we get a smaller number.

Although David did not come out and tell the students that multiplying by a number less than one yields a product less than the number, the discussion was teacher-centered with little input from the students beyond one-word answers.

The second stage of David's lessons consisted of activities to solidify what had been discussed in the introductory stage of the lesson. This usually involved going over homework from the previous night, or doing small-
group problem-solving activities. During these discussions, David would react to answers given by the students and lead them to the answers being elicited much in the way described in Category 2. This pattern of behavior was reinforced by the structure of the field experience. David often prepared lessons upon arrival at the school, sometimes being asked to go over the homework of the day before. In recounting one such instance in his journal, David wrote:

Their homework was comparing fractions. Pretty easy, I thought. Just a common denominator, change the numerators respectively, and voila - you got it.

This lack of preparation made David rely on old habits, thus reinforcing his default mode of asking leading questions.

**Summary of David's Beliefs and Behaviors on His Role in Conducting Discussions After the Second Quarter**

The lack of being challenged by the university supervisor on his behavior in conducting discussions and of appropriate modeling by the cooperating teacher left David's approach to discussion virtually intact after the second quarter. The questioning mode David used resembled a form of recitation with most interactions occurring between the teacher and the student. The tendency to prepare lessons only one day in advance at most and sometimes only one period in advance, caused David to rely on his natural instincts as a teacher, making his preconceptions and prior behavior patterns even more ingrained. A review of each category describes David's beliefs and behaviors.

**Flow of Ideas.** David's focus on being the leader of discussions affected the direction of the flow of ideas from the teacher to the students. He felt required to introduce concepts to the students before problems related to the
concept could be addressed. This belief reflected his preconceptions about his role in discussions based on his experiences in secondary school. Although desirous of developing the students' conceptual understanding, David's behavior tended to stress mathematical procedures and students' attainment of the "right" answer without giving the students the answer.

**Student/Student and Teacher/Student Interactions.** The principal mode of interaction in David's classes continued to be teacher/student interaction in the form of the teacher asking leading questions to the students. Student/student interaction took place in small-group problem-solving activities. When inquiry situations arose in the course of a lesson, David tended to revert to asking leading questions, instead of letting students work through the problem on their own. David used questioning to increase student involvement, to discipline students, and to demonstrate students' lack of understanding of a concept they professed to know.

**Justify Student Responses.** David's use of the "why" question was not to elicit student thinking but to elicit a predetermined procedural response. The doctoral student's comments after he had observed David encouraged David to seize the opportunity for students to justify their answers or to open up the discussion to the rest of the class for their reactions to a given response. Conditioning students to be ready to justify their answers was another obstacle David encountered during the quarter.

**Acceptance of Ideas.** David accepted students' ideas, but normally redirected discussion back toward a recommended instructional objective through leading questions if the idea did not make progress toward David's predetermined goal. David felt this behavior was a strength of his teaching. Comments by the doctoral student indicated the need to create a "taken-as-
"shared" approach to the establishment of meaning in the classroom, but follow-up on these comments went unattended, leaving David's beliefs and behaviors unchanged from the last quarter.

**Tasks to Promote Discussion.** The confusion David expressed at the end of last quarter about the use of manipulatives remained after the second quarter. Lack of preparation time and modeling by the cooperating teacher caused David to rely on intuitive uses of manipulatives, such as his decision to use checkers to illustrate fractions and division. The one lesson in which he prepared in advance was his self-described most successful lesson, but little changed in the external circumstances after that lesson to continue to affect change about his beliefs about using manipulatives. David perceptions of problem solving included a procedural view of the steps leading to solutions, use of problems as attention getters in the classroom discussion, and a preference for real-life problems, personalized to the class. David's use of technology was limited to using calculators as computational aids during problem solving, despite awareness of computer technology for instructional purposes.

**Teacher Intervention in Problem Solving.** David continued three practices exhibited in the first quarter: asking leading questions when students were stuck, giving hints to redirect students' thinking, and breaking down problems into simpler parts. David continued to have the problem of sometimes focusing on one group or individual to the exclusion of the rest of the class.

**Orchestrating Discussion.** Although not a lecture, David's method of questioning remained teacher-centered. Despite having student-centered discussions modeled in the mathematics methods and general methods
classes, the lack of modeling in the field did not allow David to move toward the teacher-centered mode of instruction recommended by the *Standards*. David's plan of instruction favored an initial teacher-led discussion to introduce concepts, followed by activities to reinforce the concepts. David's lessons rarely departed from that format.

In summary, David held fast to most of the preconceptions about conducting discussions in the mathematics classroom and was confused about how to put the recommendations of the *Standards* into practice in his own teaching. He wanted a course that would show him how to teach in that way. Glimpses of the kind of feedback David was seeking were seen in the doctoral student's comments, but were not followed through on by the cooperating teacher or university supervisor.
CHAPTER VIII
THE CASE OF MARY

Background.

Mary entered the mathematics education program as an enthusiastic 20-year-old junior, ready to make a contribution to mathematics education. She came from a large family with six children. She had two brothers who were approximately her age, and three younger siblings who were being homeschooled by her mother at the time of the study. Mary was successful in her college studies, entering the program with a 3.8 overall G.P.A., and a 3.6 plus G.P.A. in her mathematics classes.

Mary completed Grades 9-11 in a small rural high school and had the same mathematics teacher during those years. The teacher’s approach to teaching mathematics was routine-like, something to which Mary responded with academic success, but with emotional indifference. However, after moving before her senior year, she had a teacher to whom she credited her desire to go into mathematics education. She described him as enthusiastic, personable, and caring. Mary’s preconception of mathematicians before having her 12th-grade teacher was one of people with their heads "up in the clouds." As a result of learning mathematics with this teacher, she realized a person could be a mathematician and still have the enthusiasm and caring nature she saw in herself.
Mary carried these qualities into the mathematics education program. At the time of the first interview and throughout the study, Mary expressed concern about the affective aspects of teaching mathematics. She wanted to create a classroom atmosphere in which students would feel free to contribute without the threat of humiliation. Mary was aware of the need to accept students at different levels, but felt that with encouragement students could develop the same kind of confidence she felt about doing mathematics.

Mary's experiences in working with gifted children in a summer program affected her confidence in her ability to communicate her understanding of mathematics and her conviction in the capacity of children to learn mathematics. She recounted how she had been asked by the students for help with matrices. After having read over the textbook about the subject, one with which she had not had prior experience, she was able to "figure it out," and help the students. The students' abilities to write research papers in mathematics led her to believe that teachers underestimate students' capabilities.

Mary was very intense about learning mathematics. She told about getting mad when she could not figure out a problem posed to her by one of her brothers. She would isolate herself and work on the problem until it was solved. The combination of these experiences gave her the confidence to teach mathematics at any level of secondary school. She felt her ability to understand mathematics and exploit textbooks for the information she had not already learned prepared her to teach any class.
Incoming Experiences and Beliefs Concerning Discussion in the Secondary School Mathematics Classroom.

Mary's prior experiences did not mean that she would teach in a manner similar to her previous teachers, but they did influence how she perceived her role in the mathematics classroom. The following sections recount Mary's preconceptions about the teacher's role in conducting discussions in the mathematics class.

Category 1: Flow of Ideas

The mathematics classes Mary experienced in secondary school were primarily teacher-centered. The teacher introduced new ideas to the students through some form of lecture. Students were generally passive receivers of information, and the teacher was seen as the authoritative source of information.

Two of Mary's experiences deviated from this basic pattern of introducing ideas into the classroom. In the 9th grade, Mary's teacher decided to utilize small groups as the sole method of learning. Students worked in groups in a form of mastery learning and were allowed to continue on with new material only after passing required tests. Although not introduced through lectures, the material was given through a series of worksheets the students worked on before taking the tests. The teacher did little other than monitor the progress of the students by correcting the worksheets and administering the tests. Although Mary didn't think this experience had been very effective, she believed learning the material by herself helped her to not rely totally on the teacher and to think for herself.

During Mary's senior year, her teacher presented material through interactive lectures in which the students were free to ask questions as the
The teacher presented the material. The teacher sometimes assigned problems from the subsequent section in the book even though he had not completed introducing the material in the section. This forced the students to read the book before doing the homework, and then the teacher answered questions on the material during the next class. Even though the students had not received a lecture before doing the homework, information came from a source outside of their own thinking. The net result was a teacher-centered class in which students are passive recipients of mathematical knowledge.

Mary already was leaning toward creating something different from a teacher-centered classroom that follows a set routine each day the students come into the classroom. She did not want the teacher to be perceived as the one with all the answers. She wanted to incorporate a tactic modeled by one of her university professors in geometry in which teachers act like they did not know the answer. When asked why she would use that approach, she responded:

Because it will be funny when the teacher doesn't know. [The students] have to figure it out, and they know that you're not going to come in and tell them. Sometimes they'll get lazy in their minds when [they] know you're going to tell them the answer. But, if you don't always tell the answer, and they think they have to figure it out, then they probably will.

Mary wanted to move away from the teacher always disseminating information to a classroom where the students are capable of thinking for themselves and coming up with ideas on their own.

Mary was willing to try other things to promote this type of classroom. She was ready to change the seating structure away from the normal series of rows to a more informal arrangement. Although Mary had been enrolled in the mathematics education program for only one week, she discussed the
possibility of introducing concepts with a problem, and using wait time to allow students to introduce their own ideas into the discussion. Both of these concepts came from the first week of mathematics methods classes.

Despite this openness to having students generate ideas in the classroom, Mary's tutoring experiences resembled the teacher-tell mode of introducing ideas. In describing the discussion she had with students she was tutoring, she said she could "explain to them [the concept], even though they've never been able to understand this in their whole life." The teacher as explainer was still a powerful image for Mary as she entered the program.

Category 2: Student/Student and Teacher/Student Interactions

Despite having worked for almost a full year in small groups in her algebra class, Mary had little in-class experience in interstudent discussions. Most of the interactions in her mathematics class were between the students and the teacher while going over examples or problems from the homework. When questions arose, her teacher would normally respond with a question or by explaining the concept in a different way.

Most of the student/student interactions took place outside of the normal classroom routine, either when there was time for students to work together at the end of the period or when students worked together on problems outside of the classroom period. In describing the group of students she worked with outside of class during her senior year in high school, Mary said:

We always got together out of class. We'd go to someone's house for a couple of hours and we'd study a couple of days before the test. So we did our own groups. We'd say, "What about this?", and we'd always explain and we'd always talk about it ourselves. I've had group experience, but not formal in a classroom.

Mary worked with these same students while in the classroom. she said:
We sat in this corner, and we'd come in and I guess we'd talk about some stuff. There'd be some question and we'd ask how did you do this? And we'd try to figure it out, and I would show them or they would say you have to do this. One of them was OK in math but he was like real confident, and it was kind of good because, he would say, "NO, you have to do," and he'd explain it a whole different [way], and it would be wrong, but you could almost see that he could be wrong and you had to convince him that he was wrong, and you'd become more confident in your math skills.

Mary considered these interstudent encounters to be a form of debate.

As Mary entered the teacher education program, she wanted to encourage student/student talking in her classroom, because she believed it was effective for her as a student. However, at this stage of her development she was cautious about how it would take place. She liked the idea of having students work in small groups, and expressed the intention to use them when she begins to teach, but expressed several concerns about their effectiveness for all students. She considered herself to be a motivated student who worked well with students, but felt other students had a tendency to "goof around," or want to give up when confronted with a difficult problem, making the small group work ineffective. Unlike her own 9th-grade teacher, Mary recognized her responsibility to monitor the activity in the groups, if she were to use them. She expected students to use the small group forum to debate possible solutions to problems being discussed.

Category 3: Students Justify Their Ideas

Mary's high school teachers rarely had the students in her classes justify their ideas to the rest of the class. Mary was required to justify her ideas most often when she met individually with the teacher. Her experiences in working in small groups outside of class helped Mary see the importance of being able to justify your ideas to one another.
Mary expressed the desire to have students explain what they were thinking and why to the class. If students introduced an idea to the class, she would have them come to the chalkboard and explain to the class what they were thinking. She would open up the discussion to the rest of the class to see if people were thinking of other ways to look at the problem.

Mary made the analogy between discussions of this kind with those held in other disciplines. She felt effective discussions were those in which students justified their ideas. She said:

To say something in English class you have to have a logical basis to stand on, if you're going to have any kind of valid argument. And it's the same in math. If I'm going to say this equals this, I have to follow logical steps through and support my answer.

In Mary's opinion, sound reasoning is the basis for effective discussions, and is something she would require in her classrooms.

Category 4: Acceptance of Ideas

Acceptance of ideas in Mary's classes was determined by the teacher. When students presented answers to a problem or contributed ideas to the discussion, Mary's teachers evaluated the responses and then either encouraged the students for their effort or moved on to other students, if the answer was incorrect. Even though Mary frequently came up with her own ideas about different ways to approach problems in class, she rarely shared those ideas in class. Normally, she would defer to the solution obtained by using "the formula," probably the method recommended by the teacher.

As a teacher, Mary felt she would encourage students for their response, if correct, and give them a chance to redeem themselves or ask someone else to help the student out, if the response was incorrect. Mary would do this for two reasons. First, she was concerned for how the students would feel if their
answers were put down. Mary had strong feelings about safeguarding the integrity of individual students, because she felt negative feedback from the teacher would cut a student out of the discussion and possibly contribute to the students' low self-esteem. Second, by asking students to help one another out, more students would contribute to the discussion and help develop the idea that the teacher is not the sole possessor of knowledge in the classroom. This second idea follows from the tactic expressed earlier in which the teacher plays "stupid" to generate students' input.

Category 5: Tasks that Promote Discussion

Tasks presented in Mary's classes rarely went beyond textbook problems. The problem in Scenario II reminded Mary of the problems she saw in textbooks she used in school. When asked if she had seen problems like this, she responded:

Yes. The entire question. It's like one in every algebra math text. They tell you one side is so much longer and give the area and you figure the dimensions.

She felt this type of problem was not exciting and did not challenge students' thinking.

Mary made the connection between cooperative group work and the types of problems the teacher assigns. She believed an effective task was to assign a challenging problem that deviated from the problems covered in lectures. This would necessitate small group collaboration and get the students to think. A second aspect of an effective word problem Mary identified was to make the problem personal for the students. By inserting their name or personalizing the problem situation, Mary felt she could get the students to relate to problems structured in that way and help them understand the problem better. At this point in the study, Mary was the only
student who made mention of the teacher from Scenario I's use of student journals, a task Mary felt she would assign to students in her own teaching.

Category 6: Teacher Intervention in Problem Solving

Mary's teachers utilized a variety of strategies when helping students who had gotten stuck on a problem. First, teachers provided a simpler example to illustrate the concept. Mary gave the illustration of substituting numbers for variables into an expression involving exponents in order to help the student see the algebraic relationship. Second, Mary's teachers provided hints to get the student involved in the problem-solving process again. Third, Mary's teachers worked out the entire problem to model the problem-solving behavior they were using. Above all, her teachers never just gave the students the answers.

Of all the behavior illustrated by her teachers, this was the one Mary seemed the most comfortable imitating. When asked what she would do when students got stuck on a problem, she said:

Some of the same. I would give them hints sometimes. I guess each case would be different. If they came out of class, and they worked a lot, I would go through the problem with them and show them how to do it, with them. Just go through the whole thing with them until we got the answer. I also might reexplain it with a different problem, and see if they can apply that into this problem. Other times, I might give them just a real little hint and say your assignment by tomorrow is... Just challenge them to figure it out. I had a computer science teacher that would do that to me, and you didn't care what homework you had because you had to figure out that problem. He challenged you personally. So that was a good way.

Mary was aware of the need to evaluate each case individually before making teaching decisions. She seemed to thrive on the personal challenges teachers gave her and expected other students to respond in a similar way.
Category 7: Orchestrating Discussions

An overall description of Mary's classes would be a lecture in which the teacher explained the concepts to be learned. Very little activity in Mary's classes was directed toward students discovering mathematical relationships on their own through tasks carefully assigned by the teacher. The homework-lecture-examples format described in the other cases and by Goodlad (1984) was, again, the principal operating mode in Mary's classes. The teacher is the principal conduit through which information is given, problems are solved, and concepts are conceived.

How Mary would actualize her intentions to deviate from this pattern was not fully thought out at the time she entered the program. One thing she was certain of trying to accomplish was increasing the involvement of the students. She had already grasped the idea of introducing concepts through problem-solving situations in order to promote student thinking about the concept. She envisioned first starting off with a problem situation, moving into an explanation, and then allowing students to ask questions related to the topic.

When asked to choose which of the two scenarios in the screening questionnaire reflected how she would teach, Mary opted for the first scenario in which students worked in groups. Although she saw the need for lecture, she felt the cooperative learning situation, with students working in pairs, was more effective. She saw the role of the teacher as an instigator, someone who throws out a question and directs responses, allowing students to be wrong for a while until they see the error of their thinking.
Review of Mary's Preconceptions About Her Role in Conducting Discussions in the Mathematics Classroom

Mary came into the mathematics teacher education program as an enthusiastic young woman who wanted her students to become confident in their ability to do and understand mathematics. She turned to mathematics education after having a mathematics teacher in her senior year whose own enthusiasm made mathematics appealing to Mary. Although Mary was not able to fully envision how she would change her teaching methods from those used by her previous teachers in order to make the difference she wanted, she had already become affected by the mathematics methods course in which she was enrolled for the first quarter after only one week of attending classes. Her prior experiences and beliefs in the seven categories are summarized below.

Flow of Ideas. Discussions in Mary's mathematics classes in secondary school were primarily teacher-centered. Ideas were initiated by the teacher with virtually no student exploration of concepts prior to the teacher explaining concepts to the students. Mary identified teacher behavior that would help move away from this type of classroom, enabling students to have experiences in which the teacher was not the central figure in discussions.

Student/Student and Teacher/Student Interactions. Most discussions in Mary's mathematics classes involved teacher/student interactions. Students were infrequently given the opportunity to work together and discuss mathematics problems on their own, even in the algebra class that was conducted totally in small groups. Mary expressed the desire to move away from this type of approach by encouraging interstudent interactions by utilizing cooperative-learning groups to solve problems. However, she had
concerns that students may "goof off" in small groups without close teacher supervision.

**Students Justify Their Ideas.** Despite not having had teachers who required students to justify their answers in the classroom discussion, Mary believed students should be able to justify their ideas to the rest of the class as a general principle of discussion in any setting, not only in mathematics classes.

**Acceptance of Ideas.** Ideas presented by students in Mary's classes were evaluated by the teacher for their conformity with suggested methods. Mary would change this process in classroom discussions by encouraging students for their contributions and soliciting alternative methods of solution from the students in order to establish the idea that teachers are not the sole authority in discussion.

**Tasks That Promote Discussion.** The textbook was the principal source of tasks assigned in Mary's classrooms. Mary felt tasks should challenge the students and extend beyond problems covered in lectures to include non-routine problems requiring small-group collaboration in order to solve the problem. Mary intended to use the technique of personalizing problems in order to generate students' interest and to make the problems more realistic. Mary was interested in the use of student journals as a task to assess student thinking.

**Teacher Intervention in Problem Solving.** Mary expressed the intention of imitating her previous teachers' behaviors when intervening with students stuck on a problem. These behaviors included providing simpler examples for the students, giving hints to the students, and modeling solutions for students. Mary expressed the possibility of letting students struggle with a problem on their own, as well.
Orchestrating Discussions. Mary's classes generally followed the homework, lecture, examples format described by Goodlad (1984). Mary believed she would deviate from this pattern to make mathematics class more exciting, but had not begun to formulate methods by which she would accomplish that goal. One idea expressed was to introduce concepts using problems. This was confirmed by her preference for Scenario I from the questionnaire, in which small-group problem solving was utilized, although after, not before, the concept was introduced.

Mary's Perceptions of Her Role in Discussion After Participation in the Mathematics Methods Course and Related Field Experience.

Mary was a very intense student, and her intensity manifested itself in several ways during the mathematics methods course and in the field experiences. Mary had stronger feelings about several aspects of teaching the other preservice teachers in the study did not exhibit. Because she was looking to do things differently in her classes, Mary reacted positively to the methods class instruction and the experiences she had out in the field.

Mary was placed in a second-grade classroom made up of 21 predominantly white students in a suburban community close to the university. Her cooperating teacher had been teaching for 16 years and had supervised preservice teachers in the past. The cooperating teacher was the only teacher in the elementary field experience who was familiar with the Standards and who was familiar with literature from professional journals like the Arithmetic Teacher.

The classroom was structured for group learning on the mornings Mary was in attendance. During those times, the cooperating teacher worked with her reading groups, while the remainder of the students worked on "tub" activities. Because of this, Mary never had the opportunity to teach a lesson
to the entire class at any time during the quarter, a concern of hers when she finished the quarter. All of Mary's time was devoted to working with individuals or groups of three or four students on tub or self-made activities. Because the cooperating teacher had preplanned the bulletin boards for the year, Mary substituted a tub activity for her bulletin board requirement.

Throughout the field experience and methods class, Mary exhibited five characteristics that distinguished her from other members of the class. First, Mary had a great deal of enthusiasm for teaching and learning. A vibrant personality, Mary contributed frequently to the discussions in the methods classes, rarely being reluctant to share her ideas with the class. Her cooperating teacher called her behavior with the children "animated." Mary recognized this quality in herself and felt enthusiasm was a quality of a good teacher. She often spoke of making her teaching exciting for the students. Throughout the quarter, Mary became aware of the contrast between her style and that of the cooperating teacher. Mary marveled at how calm the cooperating teacher was, while at the same time, how effective she was. Mary came to appreciate this quality and worked on letting her enthusiasm be expressed in a quieter way. The university supervisor noted Mary might need to control her enthusiasm in order to not dominate the talk that goes on in the classroom.

Second, Mary was very creative. The expression of her creativity stems from her desire to make mathematics more exciting. During her field experiences, Mary frequently adapted tub activities to generate more excitement in the class. For example, after having played a form of bingo with the children to improve their arithmetic skills, she decided to have the children play "speed" bingo, in which the students had only a few seconds to
respond before she went to the next card. Mary did this several times during the quarter.

Third, Mary balanced her creativity and enthusiasm with a reflective approach to her teaching. She did not change things only for outward effect, she reflected on the results to see if the children had in fact learned from the change. Mary's behavior resembled a form of action research. Her university supervisor noted:

In playing one game she changed the rules in the game and observed the differences that it made. It was sort of a teaching experiment.

She would try approaches in several different ways and evaluate the results. Mary's journal entries contained many comments indicating an examination of her behavior. On reflecting about her work with the students in small groups, she wrote:

I believe [my working in small groups] is very helpful. It teaches you a lot because you can constantly evaluate yourself, think before the next time, and use a different approach.

The university supervisor commented on this type of behavior and encouraged Mary to continue to reflect in this manner.

Fourth, Mary extended her reflection to the learner as well as to the learning process. Her journal entries were replete with references to the individual characteristics of the students in her class. When doing activities with the students, Mary asked the students whether or not they liked mathematics. Not to her surprise, she found the students generally liked mathematics. This caused her some concern, because she wondered how the students developed such poor attitudes toward mathematics by the time they entered high school and how teachers could foster better student attitudes. Mary noted the different ability levels students exhibited at even this early
level, and attributed this to a Mathematics/English split in abilities she had observed among students. She wondered, too, as to how much effect parent involvement had in student differences she observed. For example, one second-grader was able to do multiplication, while others were still dependent on manipulatives to do addition.

This leads into the fifth characteristic Mary exhibited, a genuine caring for the students, a characteristic noted by the university supervisor. Mary wrote in her journal about her appreciation for the caring actions of the cooperating teacher in general, noting specifically the handling of the death of a student's father. Mary recounted on several occasions her concern for students she felt were falling through the cracks. She was concerned about children's self images and recounted in the methods seminar an encounter with a boy in her class who already referred to himself as "dumb," while he was one of the better students in the class in English and a good mathematics student.

Coming from a family in which her younger siblings were being home-schooled, Mary was concerned about the entire education system as well. Mary wanted to see improvement in mathematics teaching, and was encouraged by the Standards, the contents of which were stressed by the methods instructor. Mary was ready to hear about suggestions the Standards offered. The following sections discuss the impact of the field experiences and the methods instruction on Mary.

**Category 1: Flow of Ideas**

The Standards call for classroom experiences in which students are required to make conjectures, test them, and look for ways to demonstrate mathematical properties and principles arising out of the investigations. This
type of student-centered classroom was discussed in the methods class, and
teacher behavior during discussions to promote such learning was modeled
by the methods instructor, although not always in learning mathematical
concepts.

Mary's field experience contained opportunities for her to practice some
of the principles taught in the methods class. The tub activity system fostered
student investigation of ideas, and the cooperating teacher conducted
occasional activities with the whole class in which students investigated a
concept and communicated their findings to the rest of the class.

The following examples illustrate this approach. During a science
experiment, students were asked to name an item based on information
about some of its properties. Students' suggestions were listed and defended
by those who had proposed them, and then the class voted on what the item
was. Students' ideas were elicited, a technique the cooperating teacher
utilized in mathematics as well. Students were given the responsibility of
leading a group activity involving the calendar. In teaching the students
about the calculator, the cooperating teacher had the students explore keys by
pushing the keys and recording the results. Students were then to look for
patterns in the results to predict how the calculator was counting. The ideas
examined in these activities originated with the students, not the teacher.
The cooperating teacher indicated it took several years of working in this
manner in the lower grades before students were comfortable with activities
such as these on their own and in groups.

Mary noted how this approach to introducing ideas differed from her
experience. She considered this revelation to be an "ah-hah" moment for
her. These experiences reinforced the techniques suggested in the methods
class. The combination of these two experiences helped change Mary's view of how she would be teaching. When asked about changes in her beliefs about teaching her own class she said:

Well, maybe that idea of the teacher as not being the one who teaches. So I'm not going to be just talking the whole time, lecturing.

Mary began to move away from being principally a disseminator of information in a lecture mode.

Mary began to replace her prior beliefs with new alternatives to lecturing. She talked about introducing ideas by having students investigate problems that challenged their thinking and prior conceptions. She felt group activities provided for the kinds of interactions that helped students present their ideas about a concept or problem. In describing the benefits of group interactions, she stressed the importance of letting the students introduce their ideas to the rest of the students. She said:

That's what's real good. Sometimes you might not think of something exactly, but you can participate in a different part [of the discussion] and offer a different idea, and you come to a whole solution. Or one person has a different idea and you go off on theirs for a while, and you come to maybe a dead end, or some answer you think is fairly OK. Then take someone else's idea that you would have never thought of because, people think so differently.

Mary discussed the possibility of having students do research papers, like the ones the students did in the summer camp, and have them present their ideas to the class for debate.

Mary's behavior in the classroom confirmed this change in beliefs. The activities she conducted as part of the classes predetermined activities and those she developed promoted student investigation and input. In one particular activity, students had to place bears on streets and avenues so that no two colored bears would be on the same street or avenue. Mary
participated in the activity as a member of the group, conveniently choosing to go last in order to let the students debate the difficulties when it was her turn and could not successfully put her bear down without duplicating her color on a street or avenue. When that situation arose, students actively debated the problem with little guidance from Mary. Mary commented in her journal on the importance of helping the students see that there is not only one "right" answer for a problem, but that many of their ideas can be used to solve a problem. In writing about the puzzle she made for the class, she noted the puzzle reflected ideas talked about in the Standards recommending activities that "have students initiate questions and have them play the role of the teacher."

**Category 2: Student/Student and Teacher/Student Interactions**

A transition began to occur in how Mary perceived interactions would take place in the mathematics classroom between students and the teacher during discussion. Although Mary never subscribed to a classroom discussion format that featured principally lecturing, her first quarter in the mathematics teacher education program introduced Mary to new ways to organize the classroom experience to engage the students in discussion. Each component of the program had its impact in the first quarter.

First, the methods class introduced Mary to new techniques for enhancing teacher/student interactions in the mathematics classroom. Among the ideas Mary identified as being modeled by the methods instructor were the concept of wait time; making eye contact with the students when asking them questions; answering a question with a question, a technique Mary referred to as Socratic dialogue; not asking questions that can be responded to in a single word; not asking generic questions like "Do you
understand?"; and not addressing students by name with questions. Mary accepted these techniques, except she felt after a question had been posed to the entire class, individual students could be asked a question. The methods instructor modeled these techniques for Mary during the quarter and supported their use with results from related research, a fact to which Mary referred.

Because of the structure of the field-experience class, Mary was only able to practice her questioning skills in one-on-one situations or with small groups of three to four students. In doing her crossword puzzle with students, Mary tended to walk the students through the exercise with leading questions. She never just told students information, but asked questions to help them discover it for themselves.

Second, the importance of promoting student/student interactions was introduced by the methods instructor and reinforced by the field experience. This was done mostly by the encouragement of using group work and occasional large-class discussions in which the methods instructor was noticeably absent from the discussions. The effectiveness of group work in the field experience convinced Mary of the feasibility of their use in her own classroom. Mary referred to her field experience as:

Overall, I think this has been a great learning experience that I believe I'll look back on very fondly. I think the kids impressed me sometimes at their abilities to reason when working together in a group.

Mary was able to see the more positive side of having students work in groups, after her negative experience in her algebra class. Mary's journal comments and interview responses reflected a desire to extend the use of groups into more teaching situations. After she had done her crossword puzzle with individual students, she wrote:
I think groups are really the way to go, because later, as one girl was doing it, a friend came out and watched for a minute and then started helping. I don't know how effective I am just sort of watching and guiding while they play. I think a group of 2 or 3 students working together would profit well from being left alone to figure the entire thing out.

Mary recounted this same type of possibility in many classroom instances. The transition was not total. Mary continued to express some concerns about students who did not remain on task.

**Category 3: Students Justify Their Ideas**

Mary maintained the principle of having students justify their ideas in discussions in mathematics classrooms. Mary believed in requiring students to present their reasons for the answers they give. She noted the ideal situation would be if students required justification from each other. However, if in the course of discussion, students were not inquiring of each other how and why they answered the way they did, Mary would intervene and ask the question herself.

This principle was reinforced by her experiences in the methods class and in the field. As already indicated, the methods instructor stressed the importance of asking the "why" question. This was modeled in methods utilized by the cooperating teacher. Students in Mary's second-grade class were constantly asked to explain how they had arrived at a particular response, even for simple addition facts. The cooperating teacher stressed the use of strategies for doing computation. Two strategies the students learned were using doubles to evaluate the addition of one number and another number one less than it, and in adding 9 to a number, they could first add 10 and subtract 1.
The cooperating teacher shared how students needed to be indoctrinated into not just giving an answer, but also to be ready to defend that answer. This de-emphasis on answers and re-emphasis on reasons was supported by Mary. Mary believed her task as a teacher was to show students that how you arrived at an answer was just as important, if not more important, as the answer. In her interactions with the students, she frequently asked students to justify their thinking for her or for the rest of the group in which they were working. Mary was amazed at the ability of her second-graders to think and reason. She was even moved to write in her journal:

I'm amazed again at how logical and bright second graders can be. I sometimes think that they may actually **THINK** more in the course of a day than the average high school student.

Mary was skeptical of school systems in which it could be true that second-graders think more than high school students. This possibility fed her desire to make a difference in teaching.

**Category 4: Acceptance of Ideas.**

As indicated in her preconceptions, Mary did not want to be perceived as the main answer giver in the classroom. From the methods class, she saw the teacher could play the role of the student so that students would not rely on the teacher to get answers. Mary noted that even in her methods course, students responded differently to tasks. Some were preoccupied with getting the "right" answer and asked the methods instructor to verify their responses, to which the instructor responded, "Is it right?" This modeled for Mary that the teacher need not always be the judge of correctness for work done in class. Students should be ready to determine whether or not a response is acceptable or not. Mary believed this approach helped students develop a confidence in their own thinking, rather than rely on the teacher.
Mary's behavior while working with students confirmed this belief to a large extent. When working with the bears activity, Mary let another student be the "checker," who verified the work of the other students. During the activity, Mary asked students to check on each other as they put the bears down in the rows and columns. One exchange was as follows:

Mary: OK. Is he OK Adam?
Adam: No.
Mary: Adam tell me why that is wrong. Tell him what's wrong with that. [Mary jumps in before Adam has a chance to answer.] First the avenues are great, Zack, that's fine. But here on the streets you have neighbors of the same color. We don't want that.

Mary wanted Adam to justify why he didn't think the answer was right, but didn't allow enough time to get a response. Mary's enthusiasm prevailed over her intention to have the students check each other.

Mary's beliefs and behaviors were in harmony, but it will take time to develop the self-discipline necessary to maintain the harmony at all times. Mary acknowledged the need to create an atmosphere in which students feel free to contribute without being put down. She expressed the desire to create such an atmosphere.

Category 5: Tasks That Promote Discussion

Mary's greatest change with respect to what she will be doing in mathematics class to promote changes occurred in this category. Exposure she received to teaching methods involving manipulatives, calculators, journals, and problem solving deviated the most from her prior experiences. Techniques were introduced in the methods class and were modeled in the field experience. Although the impact on discussions of the use of these techniques was not directly addressed, the different expectations placed on
students when engaged in these activities changed the nature of the ensuing discussions.

Of the four major tasks Mary identified, the use of manipulatives had a significant impact on Mary. Her reaction to their use was positive, and she indicated she would use them in a hypothetical lesson on fractions. Because the methods instructor frequently brought manipulatives into the classroom and the cooperating teacher used hands-on materials for most of her activities, Mary was convinced of their value. The cooperative teacher had Mary use beads to illustrate basic arithmetic facts and mirrors to illustrate symmetry. Students collected leaves to investigate means of classifying and analyzing data. All these activities changed the nature of the discussion by allowing students to explore concepts through manipulatives before discussing general mathematical facts.

Having started at the elementary level, Mary expressed concern about manipulative use in the secondary schools. She listened to a fellow preservice teacher describe how a well-designed lesson plan involving manipulatives had "bombed." Hearing of this apparent failure, Mary wrote the following entry in her journal:

The girl stated that she'd planned a great hands-on activity using manipulatives and everything to teach some concept in a junior high class and it just BOMBED. They didn't make any connections and didn't really even try. The woman said something to the effect of it will be hard at first, because the kids aren't used to manipulatives used in their classrooms and you must have a "Plan B." I agree that you must be prepared for anything and have a few backup plans, but I just wonder if I would constantly get negative feedback from supposedly fun learning activities, how long I would continue to plan these. I wonder five years from now how my junior class of Math Ed. majors will be teaching. Will everyone get tired of making that extra effort and getting shot down, or will we persevere and still be thinking of new, innovative ways to teach?
Mary already was concerned about how new teachers would be able to persevere in the face of students who are not indoctrinated into using manipulatives. She saw the problem of having students do an activity solely for the sake of utilizing manipulatives and not for the goal of teaching a mathematical concept. Mary said:

[My fellow preservice teacher] did a game today where she had kids try to put together shapes and leave as little space between shapes as possible. In talking to her, she didn't at first think it was a very profitable exercise. This made me think that it is important for a manipulative to be effective and not just busy work. I mean, this is something obvious, I suppose, but I think that sometimes I just see the tangible items and automatically think, "Wow! That's probably a fun and effective activity," when in fact it can be just as bad as a boring lecture that isn't thought out. I see very much the importance of good planning. There's a lot of thought and prep work that goes into an exciting and effective learning activity.

This conflict preservice teachers face is one Mary has not resolved at this point in her development, but has already done some thinking about.

Student journals were a second task Mary was introduced to in the methods class that had an impact on her perception of how students can communicate mathematics in the classroom. She considered keeping journals a revelation in teaching mathematics. She was sure she would have students keep journals when she had her own classroom. Mary demonstrated the extent of that conviction by having a girl she tutored in a church-volunteer program keep a journal. She would connect journal writing with discussion by having students write about discussions that took place in class. Mary wanted to extend writing to research papers students would present orally to the class.

Tasks involving problem solving and the use of calculators were stressed in the methods class, but seemed to fit into Mary's pre-existing beliefs system
without producing a sense of revelation. Because Mary was in the second grade, there was less of an emphasis on calculator use, although lessons introducing the functions keys on a basic calculator were given by the cooperating teacher. Problem solving was integrated into the second-grade class through the tub activities, usually in the form of a game. The activity Mary created was a crossword puzzle that required various problem-solving strategies. Mary worked individually and in groups with students on games such as placing the bears on a grid of streets and avenues, as already described. Mary said she would use thought provoking problems to introduce concepts to the students in a unit on fractions to get the students talking.

The cooperating teacher wove mathematical problem solving into the class in such a way that students were not aware of having done mathematics. A spelling activity required the students to classify words by vowel sounds and put them in a chart. The charts constituted bar graphs illustrating the number of words in each category from which the cooperating teacher posed mathematical problems to the students. This modeling reinforced the ideas encountered in the methods course.

**Category 6: Teacher Intervention in Problem Solving**

Mary expressed several beliefs and exhibited several behaviors for when students reached stumbling blocks in solving problems. Imitating what her own teachers had done, Mary said she would use simpler examples to help the student see the more complicated concept. While working on her crossword puzzle, a student got stuck on 10 minus 4. Mary intervened in the following manner:

Mary: I bet you know it. What's 10 take away 5? Do you know that?

Student: 5.
Mary: So what's 10 take away 4? It's not quite 5.
Student: 6.

Mary referred the student back to the simpler problem of 10 minus 5, to help the student obtain the answer. She inserted the hint about the answer being "not quite 5," another intervention Mary used when students got stuck.

A second practice Mary observed her prior teachers used and which she also used in her teaching was the utilization of counterexamples and nonexamples. When introducing the bears activity to a second group of students, Mary began by demonstrating a nonexample to the students. In answering a hypothetical question about how she would deal with students who added one-half and one-half and obtained two-fourths, Mary immediately responded by offering a counterexample involving money to illustrate how that response would be incorrect.

A third behavior Mary manifested while teaching was to accept the student's answer and make a statement of clarification, allowing the student to reexamine the response. In all situations, Mary would not and did not give students answers if they reached obstacles in the process of solving a problem.

**Category 7: Orchestrating Discussions**

Mary was ready to deviate from the homework review, lecture, examples pattern she observed in her own mathematics classes. Both the methods class and the field experience helped Mary develop new visions of what classroom discussions can look like and what the teacher can do to promote those visions.

Early in her field experiences Mary wrote how the "lecture" was practically nonexistent in the elementary school classroom she was observing.

I keep waiting to see the teacher stand in front of the class to explain some new concept and it never happens. Things are learned so
painlessly in many cases for the kids. They are introduced a new game or activity to teach them a new concept. Too bad this kind of "fun" wasn't put into more middle and high schools. But activities take a lot of time, both in their preparation and in their execution.

The cooperating teacher saw herself as a facilitator in the classroom. The organization of learning activities in her class illustrated that role. Her science lesson referred to in Category 1 demonstrated her role as facilitator as the students explored the object, made conjectures as to its nature, and voted on what it was.

This behavior modeled recommended practice seen in the methods instruction. Discourse, as presented by the Teaching Standards, mirrored the methods utilized by the cooperating teacher. This harmony of approaches helped solidify Mary's development toward teaching in this manner. In describing how she would teach a unit on fractions, Mary said she would start by introducing a problem for the students to consider that would promote talk among the students.

Another technique observed by Mary in the methods class was exploiting the teachable moment. The methods instructor often discussed topics brought up by the students that were not necessarily planned for the lesson. Mary exhibited similar behavior on one occasion during which the sequence 1, 3, 5 came up. Mary took the time to ask the students about those numbers. When they identified them as odd numbers, she further questioned them about the sequence 2, 4, 6. Mary displayed a flexibility in deviating from planned activities to exploit observations she made as she was teaching. She began to develop teaching methods resembling the Standards.
Summary of Mary's Beliefs and Behaviors After the First Quarter

The process of reaching Mary's goal to teach differently from her own teachers was begun as a result of her experiences during the first quarter of the mathematics education program. Mary was exposed to the use of small-group learning, manipulatives, technology, journal writing, and other teaching methods in her methods class. With the knowledge received there and the reflective observation of and participation in her field experiences, Mary developed new ideas and reinforced preconceived ideas about teaching. A summary of the ideas by category follows.

Flow of Ideas. Although not wanting to lecture when she entered the program, Mary believed that she would be the one who "teaches", that is the one who transmits knowledge to students. As a result of the emphasis the methods course put on having a student-centered classroom and Mary's placement in a class in which students investigated concepts on their own and in small groups, this belief changed to a point where Mary believed ideas would be introduced by the students. Instructional alternatives considered by Mary to promote this included student small-group problem solving, playing the role of a student, and student research papers.

Student/Student and Teacher/Student Interactions. Methods class instruction helped Mary's perception of teacher/student interactions change by introducing and modeling the techniques of wait time, Socratic dialogue, asking higher order questions, and not addressing students by name with questions. Because of the structure of the field experience, Mary was able to work only in situations engaging four or less students. The importance of student/student interactions was developed in both the methods class and field experience where their effectiveness helped overcome some negative
beliefs about small-group use developed as a result of her own high-school experiences. Mary felt small groups were the "way to go" in mathematics instruction.

**Students Justify Their Ideas.** Mary's belief in the importance of having students justify their answers was reinforced by the methods instructor's emphasis on the "why" question. Computational strategies taught by the cooperating teacher de-emphasized answers and emphasized understanding, another reinforcement for having students justify their ideas. Mary's behavior in interacting with the second-grade students confirmed her beliefs.

**Acceptance of Ideas.** Mary maintained her belief that teachers should not be seen as the answer person in classroom discussions, despite some students' desire for the teacher to validate their work, a phenomenon Mary experienced in the elementary school as well as in the methods class. This belief coincided with techniques suggested in the methods class and Mary's behavior in the field experience illustrated a harmony between her beliefs and her behavior, despite lapses in which Mary's enthusiasm overrode her ability to wait for the students to explain their reasons for accepting or rejecting an idea.

**Tasks That Promote Discussion.** The greatest changes in Mary's beliefs took place with respect to the tasks that promote discussion in the mathematics class. Through the methods class, Mary was exposed to the use of manipulatives, small-group problem solving, technology, and journal writing as tasks that affect the nature of the mathematics classroom environment and experience. The use of manipulatives had the greatest perceived impact on Mary, influencing her actual and intended behavior in the classroom. She observed lessons with their use, developed activities
involving manipulatives, and expressed intentions to use them in future lessons. Mary was concerned, however, about manipulatives in secondary schools as a result of reports from other preservice teachers about their ineffectiveness at that level. She mused about whether manipulatives created fun activities for the students that missed the educational objectives for the lesson.

**Teacher Intervention in Problem Solving.** Mary's beliefs and behaviors about intervening when students ran into problems reflected those of her prior teachers and were minimally affected by her participation in the methods class and field experiences. She relied on three basic interventions: presenting simpler examples to illustrate a concept, using counterexamples and nonexamples to provoke students into rethinking their ideas, and asking for clarification from the student. In no case would she give answers to the student, a behavior reinforced by the methods class and cooperating teacher.

**Orchestrating Discussions.** Mary agreed with the student-centered approach to discussion suggested by the *Standards* that moved away from lessons in which the teacher lectures toward lessons in which students explore problem situations and the teacher guides the exchange of ideas flowing out of those explorations. Mary observed this behavior by the cooperating teacher and the methods instructor, taking special note of exploiting what the methods instructor called "teachable moments."

Mary's beliefs about conducting discussions coming into the program were consistent enough with teaching methods taught and exhibited in the two components of the first quarter that Mary experienced little dissonance within her beliefs structure. In the areas where new beliefs were being formulated, Mary assented to those to which she was exposed, but lack of
opportunities to teach in the field experience made it difficult to assess if these expressed beliefs were consistent with observed behavior.

**Mary's Perceptions of Her Role in Discussion After Participation in the General Methods Course and Mathematics Field Experiences.**

As seen in the first quarter, Mary actively participated in the four major experiences during the second quarter: the mathematics field experience, the mathematics seminar, the general methods class, and interaction with her classmates outside of class. Each had its particular influence on the development of Mary's beliefs about her role in discussion, but the field experience was the most influential experience and the one through which the other three were often filtered.

Mary was placed in an inner-city seventh-grade classroom made up of mostly African American students. The class was physically structured for group learning with students' desks arranged in groups of four. The cooperating teacher taught one section of history and four sections of mathematics, despite having had her principal training as an elementary-certified learning-disability teacher. Mary first interpreted the cooperating teacher as having a gruff exterior, but came to appreciate her tough but caring attitude toward the students. This attitude was an integral part of the cooperating teacher's effective management of the classroom. Mary appreciated this aspect of the field experience because it helped her accomplish one of her expressed goals for the quarter, to feel comfortable in controlling an entire class.

The cooperating teacher's effectiveness in modeling classroom management was not equally demonstrated in modeling effective mathematics teaching methods. This fact was acknowledged by the cooperating teacher, who also acknowledged that Mary modeled new
methods of mathematics instruction she was trying to learn herself. The cooperating teacher was involved in a university-sponsored program for training teachers to teach mathematics through strategies involving inquiry, a fact Mary admired in the cooperating teacher. Mary expressed through several vehicles that she indeed modeled teaching techniques for the cooperating teacher.

The first two periods were mathematics classes, and the third and fourth periods were a planning period and duty period for the cooperating teacher. This extra amount of free time allowed Mary and the cooperating teacher to converse frequently about the events of the first two periods. Most of that time was spent discussing classroom management with few comments being made by the cooperating teacher about mathematics teaching. The extra time, however, did allow Mary to write at length about her experiences on a daily basis.

The university supervisor observed Mary five times during the field experience. After the lesson, during a brief conversation with Mary, the observations were assessed based on a written evaluation. This was Mary's second quarter with the same supervisor, and Mary felt the observations were generally more positive than in the first quarter, but that few concrete suggestions were made. She felt the comments were too general and did not identify specific methods on which she needed to work. Without ample time to discuss the observations, a close rapport between the university supervisor and Mary did not develop. Mary felt the practice she had in the field experience was the most important factor contributing to her changes in teaching over the course of the quarter.
The mathematics seminar and out-of-class interactions gave the preservice teachers a forum to share their experiences in the classroom and discuss common problems encountered while teaching. The Standards often were the topic of conversation, but Mary felt they had minimal impact on her teaching. She appreciated the problems they suggested, but had not integrated the Standards into her teaching in a conscious manner.

Mary continued to manifest the behavioral characteristics of the first quarter in her general methods class and in the mathematics field experience. Mary's creativity and enthusiasm were seen at all levels of her studies: choosing tasks for the students, enticing the students to be interested in discussions, getting excited when a student manifested predicted behavior in Piagetian tasks, and sharing her excitement about a mathematics quiz she and her colleagues took at the university. She believed her enthusiasm was infectious, causing the students to take an interest in what she had to present.

Mary continually sought ways to encourage students in their studies. Mary felt it important to give positive reinforcement to students in order to help develop their self-esteem and appreciation for mathematics, both goals of the Teaching Standards. A particular concern she expressed about discussion was to avoid unconsciously favoring the boys over the girls, a research result she had been exposed to in the general methods class. Mary demonstrated sensitivity to students' needs, both intellectual and social. In the early stages of the field experience, Mary worked individually with one boy who found mathematics hard to do, but, because he was very quiet, tended to be overlooked.
Mary's enthusiasm was tempered with some doses of reality. She acknowledged that not being enthusiastic did not necessarily mean being boring.

I sometimes think if I'm not enthusiastic I'll be boring - which is not true. I've had many teachers that were very calm and people loved them.

Seeing the teachers in the general methods field experience made Mary reflect on maintaining her enthusiasm. She knew that no matter how enthusiastic teachers are, they are not going to reach every student. She shared with her classmates during a seminar session late in the quarter:

I don't know who told me, it's not that you have to realize that you can't reach them, because if you realize that it's maybe admitting failure, but if you get so into it and take it so personally when you don't, that's what kills you I think. You have to harden a little bit, not be quite so sensitive to everything. You're going to pour your heart out to some kid and they are just going to crap on you. They're going to do good for a while, then forget it again. There's not any effort and you're going to keep trying and they aren't going to. But then there are some of the other kids that do. If we get so hurt by the ones that don't, maybe that's what happened to that one teacher. We're idealists. We came to make a difference. That's probably what they did too. But [teachers] become like this because they trusted kids, and [the students] didn't pull through for them.

Mary cared very much for her students, but was ready to deal with the consequences of students who did not have the enthusiasm for learning that she had for teaching.

The remainder of Mary's development will be reported in the discussion categories.

**Category 1: Flow of Ideas**

Mary's beliefs and related behaviors with respect to the source of ideas during discussions varied depending on the nature of the task in which the students were engaged. If the students were in an exploratory problem-
solving mode, the flow of ideas came from the students. In those situations Mary liked to:

ask questions so [the students] can come up with the right answers or wrong answers and other people can say why. [Then students] can defend their own answers.

The teacher in that situation begins a process of interstudent discussion by keeping questions open-ended.

An excellent example of this was an impromptu investigation of a problem precipitated by a student's question. In introducing the concept of comparing fractions, Mary had given the problem of determining whether a student, Matthew, who had to get two-thirds of his test questions correct, would be able to go to Chicago after getting 35 out of 50 on the test. Under Mary's direction, the class had determined that the student was able to go after reducing thirty-five fiftieths to seven-tenths, and finding that twenty-one thirtieths was more that twenty-thirtieths. However, at this point, a student posed the question of whether Matthew would still be able to go to Chicago if he got 34 out of 50. Mary picked up the student's idea and explored the question with the class. When Matthew was again allowed to go to Chicago with this score, another student asked what would be the lowest score Matthew could receive and still go to Chicago. This sequence of events illustrated Mary's willingness to explore student-generated ideas not planned into the lesson, a Standards-like scenario.

In contrast to this sequence, when Mary's educational objective for the lesson was to communicate and reinforce a mathematical procedure, the flow of ideas became decidedly teacher directed. When teaching students the concept of equivalent fractions, Mary introduced the concept with a problem situation in which students shared their ideas. However, once into the
lesson, a student proposed the rule of multiplying top and bottom by the same number to create an equivalent fraction. From that point on Mary directed all efforts to "pound a few points home." She described the lesson in the following way:

I wanted them to discover [the rule] and they discovered it basically by showing them a simpler example. Then once they discovered it I wanted them to see that very clear. So I would just bring that home along with the fact that whatever you do to the numerator you have to do to the denominator is a very important fact, because a lot of times if you change one or do different things to each other. I wanted to really drive home that fact. If they can get those two concepts then they would have a good chance and then I wanted them to see why it was multiplied by one. Why you're allowed to multiply by one. Any time you multiply by one it's okay.

The remainder of the lesson included textbook exercises involving equivalent fractions through which Mary led the students. Students' responses, both correct and incorrect, were examined, but the main focus was to emphasize the procedure for finding equivalent fractions. Mary did this by repeating the rule frequently after students answered a question correctly or cited the rule.

Similar behavior was exhibited with the concepts of comparing fractions and finding the greatest common factor and least common multiple between two numbers. In the lesson on greatest common factor and least common multiple, Mary introduced the strategies for finding those values without introducing them through a problem. She referred to them as "tricks" on two occasions. However, Mary was not completely satisfied with this approach. Afterwards she wrote in her journal:

I found myself at times today having trouble explaining how to get the LCM. If you have numbers like 12=2x2x3 and 30=2x3x5, it's hard to get them to see that for the answer you take two 2s and only one 3, and also one 5. I tried to tell them you take the most times a number appears in
one factor [or something like that] but it sounded as awkward as it looks now on paper.

Mary felt awkward, but received no assistance from the university supervisor or cooperating teacher to explore some of the reasons for that awkwardness.

Mary continued to utilize strategies to draw students into the discussions and inspire them to offer their own ideas. Mary gave ownership of ideas to the students by identifying the idea with whomever suggested the idea. She had groups of students put their names on solved tangram puzzles that made up a bulletin board she did. Mary frequently acted as if she were a student and encouraged students to offer and explain their ideas as a teacher. She often pretended not to understand an idea so that the student could further explicate it. Mary was flexible in accepting students' ideas, encouraging an environment in which such ideas were welcomed and honored. One of the objectives in one lesson was "to show the importance of working together in a fun, unthreatening environment." These behaviors were encouraged by the university supervisor in her comments in Mary's journal and through the student observations. The university supervisor also urged Mary to control her wait time in order to encourage more student ideas.

**Category 2: Student/Student and Teacher/Student Interactions**

Because of the nature of the first-quarter field experience, this was the first time Mary had the opportunity to prepare lessons for the entire class. Mary was able to try out several approaches in leading discussions and began to form some patterns of interaction with the students and in her behavior. Three interaction patterns emerged involving Mary's role while students interacted in small-group settings, Mary's interaction pattern in large groups when working on solving problems, and Mary's interaction pattern in large groups when stressing procedural knowledge.
Mary saw the value of small groups in order to generate ideas for discussion. If she wanted students to come up with conjectures, she felt small groups were what she would utilize. This was illustrated in Mary's first lesson with the entire class. It was a tangram activity in which Mary gave the students the pieces to the tangram puzzle and asked them to make a square. Students were then asked to work in groups and make a tangram figure of their choice. This lesson was described by Rebekah in her journal, after having observed the lesson.

1/22/93. During 1st and 2nd periods, I went and observed the classroom that Mary is in. She was doing a tangram exercise in both the classes. I saw a pattern in both classes. Very quickly the students stated that they couldn't do it. Then as they worked with the pieces, their interest grew. With less than 2 minutes into the exercise, Mary said that she would give a hint. To my surprise, the overwhelming response was that they didn't want a hint. After a while, approximately 8 minutes into the activity, the majority of the students began visibly giving up. Mary then gave a hint! This definitely renewed the students' interest and they began working on the problem again. I also noticed that as one student in a desk group solved the problem, the others quickly followed. It wasn't that they necessarily were looking at the final product, both seemed to be noticing how the others were going about the problem. Some groups seemed to work very well together. They shared their thoughts with the other people in the group. These groups typically solved their problem faster than the groups that the students individually worked on the same problem. It was interesting to see the enthusiasm grow in the students. Initially they seemed as if they thought this activity was stupid. As they worked, they increasingly became more interested in the activity.

Rebekah's descriptions indicated how Mary allowed the students to interact with one another to solve the problems, intervening only when necessary to give a hint to an individual or group. Mary gave her own description of one group's work during that lesson.

This one group exemplified ideal group behavior as they tackled the hardest anyone tried - a double tangram. There were four in the group, and they got together in two's and put their sets together. The two
groups of two would then work together, keeping the other group posted on any new findings, ideas, etc. It culminated when they both had 3 pieces left to put in and they began to work as a foursome. They conjured, guessed, checked and finally - [with a bit of help] - they tackled it. The sense of satisfaction was so high in this room you could feel it.

Mary's behavior modeled much of what she had been taught in the methods class about working in small groups.

The structure of the class in which Mary was placed and the behavior patterns of the cooperating teacher did not promote the continued development of Mary's beliefs and behaviors toward those expressed in the Standards. Most of the activities organized by the cooperating teacher were worksheet oriented, having students practice skills they were learning. Required to fit into this setting, Mary developed a style of questioning she felt was effective that helped students come to conclusions for themselves. This pattern of questioning was teacher-centered, causing the university supervisor to comment in one of her visits that Mary was possibly talking too much. When asked how her view of her role in discussion changed during the quarter, Mary thought that it might have gotten worse. She said:

[The university supervisor] said at one point to try and have the students talk more. That I was talking too much, which could have been the case for sure.

This comment did not come to the attention of Mary until the last week of the quarter, so it was hard for her to make any adjustments in her last lessons.

When Mary conducted discussions in large groups, she asked questions to lead students through the problem at hand. This line of questioning was new to the cooperating teacher, who felt Mary modeled good questioning skills for her. She described Mary's approach as follows:

The way she did it wasn't to just present it. She would ask them, "What am I going to do? How can I do that?" There was always someone who
knew what to do. She would ask them and then she would say, "Do I do this or do I do this?" She would write on the board and they'd say, "Oh no, no it has to be this way." And then she'd have someone - "Well come here and show me."

Mary did not present material in lecture form, but rather helped students arrive at responses through questions.

When asked to weigh the effectiveness of having students explore ideas on their own or having the teacher lead students through a problem or exercise, Mary felt questioning was the most effective. She believed asking the "right" questions led students to explore automatically, whereas having students work together was ineffective due to their immaturity. She saw that when students worked together on worksheets, the extent of their collaboration was each doing half the problems.

The level of Mary's questions depended on her objective in the lesson. Her lesson on equivalent fractions illustrated this point. She opened the lesson with a problem to stimulate the students' thinking. Afterwards, Mary used pieces of a Hersheys Bar to demonstrate the concept of equivalent fractions. Wanting the students to come up with a rule to determine equivalent fractions, she asked questions to solicit students' ideas.

Mary: So let's see what's going on, because we can't every time someone gives us something draw a picture and cut it and stuff. What do you want to say Jere?

Jere: Isn't 1 multiplied by 2. Like 2 times 1 is 2 and 2 times 2 is 4.

Mary: OK, OK. Let's see what he's saying. He's got a good idea. For one half equals. Now what did you tell me to do here?

Jere: Multiply

Mary: You told me to multiply. Let's see if what he says works. So if you multiply the top one by 2 and the bottom one by 2? Start out. First let's see if it works. 1 times 2 is?

Jere: 2.

Mary: And 2 times 2 is?

Jere: 4.
Mary: So one-half equals to two-fourths. So far he's right, isn't he? Let's try it again. [Asking another student.] And you want to start with what now?

Student 1: Three-sixths.

Mary: You want to multiply by three sixths? Then we get 1 times three is three-twelfths. Wait, I thought it was six-twelfths. What did we do different?

Student 2: The top number is supposed to be the same as the bottom number.

Mary: She says the top number is supposed to be the same as the bottom number.

Student: No, it's supposed to be two 6s.

Mary: You want to try two 6's. She wants to try two 6's. OK. 1 times 6 is?

Student: 6.

Mary: Two times six is?

Student: 12.

Mary: 12. Does that work?

Students: Yes.

Mary: So we have one-half equals six-twelfths.

Mary acted as a facilitator for the students' exploration of the relationship between two equivalent fractions.

However, once the general rule was established, Mary changed her questioning to drill the students on the rule. The questioning in that segment of the lesson involved lower-level questioning in which Mary leads the students through several exercises involving equivalent fractions. This type of questioning is illustrated by the following exchange:

Mary: Are we getting the idea here? What about. Wow! This might throw you. 10 over 15 equals 40 over? Tara.

[Tara is hesitant to answer as another student shouted out the answer.]

Mary: Don't worry. You get it wrong, you get it wrong. Just give it your best shot. Come on. OK. What we do to the top, what do we also have to do? Sure. OK. Write it down. See what you're doing. OK. Let's see if you guys agree with this.

Student: I told you 40 over 60.

Mary: Well, good job. Let's see if you're right. 10 over 15. To get to 40, what do we do?

Several Students: Multiply by 4.
Mary: Everybody see that? To get from 15 to 60, you multiply by?
Students: Four.
Mary: Because what we do to the top of the fraction, we must also do to the bottom. OK. Same exact thing. That's so important guys. OK.

Mary began to ask lower-level questions to drill the students on the rule she reiterates at the end of the problem. Characteristics of these types of exchanges were that Mary did the majority of the talking, asked leading questions, clarified students' thinking for them, repeated responses given by the students, and asked for agreement by the remainder of the class. Mary's behavior was similar in other lessons emphasizing mathematical rules such as finding the greatest common factor and least common multiple.

**Category 3: Students Justify Their Ideas**

One objective Mary had for her students was for them to be able to understand the reasonableness of mathematical concepts and procedures. She did not want her students to merely memorize mathematical facts, but to be able to understand the mathematics behind the facts and to see mathematical concepts as being reasonable. Mary felt this was one area in which her teaching reflected the *Standards*. The cooperating teacher noted this emphasis, commenting that Mary did a better job building concepts and "reasoning" with the students than she did. Mary observed that the cooperating teacher began to ask students "why" more often as a result of observing her frequently asking the students the same question.

Mary exhibited several behaviors in actualizing these beliefs. Many times in stressing the reason why a mathematical fact was true, Mary provided the justification and expected the students to understand it. She believed that if the theory justifying mathematical principles was explained well enough, students would appreciate the theory more and not just
memorize facts. An example of this occurred when Mary was teaching her lesson on equivalent fractions. When the students had suggested the principle of multiplying numerator and denominator by the same number, Mary led the students to see that this was the same as multiplying by one, therefore not changing the value of the fraction. Once this principle was demonstrated, Mary reiterated the principle in the discussions whenever possible.

Another behavior was asking simple questions to elicit the students' thinking. A typical aspect of Mary's lessons was "the questioning of the students so that they have to figure out why something was right." Besides simply asking why, Mary asked questions like "Are you sure?", "How did you get that?", and "What do you think?" Although these questions stressed the importance of the students being able to reason mathematically, not all of them were aimed at having students tell what they thought. Students' ability to reproduce the accepted argument for a concept was sometimes sufficient justification.

**Category 4: Acceptance of Ideas**

Ideas and responses presented by students in Mary's classes were received without judgment. This created an environment in which students were eager to respond. Mary did not normally have students raise their hands in order to contribute to the full-class discussions. Mary made one of several responses when answers were given.

First, she exploited student responses by going with the suggestions made by the students, right or wrong. This was seen in the early part of the lesson in which Mary was trying to establish the relationship between equivalent fractions. After a student suggested multiplying the numerator
and denominator by two in order to demonstrate that one-half was equal to two-fourths, Mary carried out the steps suggested by the student. Similarly, when another student suggested multiplying one-half by three-sixths to obtain an equivalent fraction, Mary carried out the steps to show that they led to a contradiction of an established fact.

While doing a lesson on solving word problems, students posed questions that went beyond the worksheet Mary had prepared. She was open to their ideas and allowed the class to explore the questions raised by the students. Mary was pleasantly surprised by this behavior. She wrote in her journal:

I couldn't believe how many times students wanted to go beyond the questions. In the problem with Hani's lawn-mowing business they got a wrong answer of 486 hours. Someone asked how much would Hani make if he worked 486 hours. I said OK, let's just estimate a little and find how much Hani would make if he worked for 500 hours. It came up to $3,000. Someone wanted to know how many days that would take, so I said at first "assume Hani works 40 hours a day." Everyone was ready to go on. Then one kid said, "how can you work 40 hours a day?" I said "oops, let's say 10 hours a day." We figured it out that he'd have to work 50 days. Then we figured out that was about 7 weeks. I was really surprised at the kids' enthusiasm, involvement and intellect.

Her ability to adapt to the students' ideas, created an environment in which students could be creative and enthusiastic.

Another way Mary dealt with students' responses was to ask for agreement from the members of the class. She often asked the students to vote on whether or not a statement by one of the students was acceptable or not. This practice was generally accepted to the point where students began to ask for a vote. The cooperating teacher appreciated this tactic and mentioned it among the ways Mary dealt with students' responses. She commented that
when a vote was near 50-50, the class would then work out the problem on
the board to see which idea was more reasonable.

Mary didn't always exhibit those characteristics. During the third
interview, when critiquing the lesson she taught on equivalent fractions,
Mary felt she could have better exploited students' ideas. When one student
came to the board to demonstrate that a pizza cut in six or eight slices was the
same, Mary corrected the student's drawing rather than asking the class to
comment on his work. She felt she could have exploited that situation better,
although she did believe she looked for those situations to exploit in other
lessons. She felt this might have been due to her anxiousness to get to the
concept being taught and the constraints of time.

**Category 5: Tasks That Promote Discussion**

Some of the most significant changes in Mary's beliefs about discussions
during the first quarter were a result of being exposed to different tasks to
promote discussion. The field experience of the second quarter allowed Mary
to solidify her beliefs about their use. Among the tasks that had an impact on
Mary were the use of manipulatives, problem solving, student writing, and
technology. The field placement challenged Mary's development in this area,
since the cooperating teacher was in the process of being exposed to these
same tasks and was learning how they could be incorporated into her own
teaching, often looking to Mary to model some of their use.

Problem solving was a task Mary consistently utilized throughout the
entire quarter, starting with the first tangram lesson and ending with her
lesson on comparing fractions. Several aspects of Mary's use and perception
of problem solving emerged. First, Mary used problems as an "attention
getter" at the beginning of a lesson. Mary used several different techniques to
do this. In the tangram lesson, each student was given the task of making a square with the tangram pieces, before moving into group work. She used a "rain storm" activity to demonstrate the necessity of having students work together. She posed the problem in which her roommate "dissed" her date when he demonstrated his ignorance while ordering their pizza. In sharing these ideas with her colleagues during a seminar session, Mary said:

I think the biggest thing is to start the class. If I start and I get everybody's attention in the beginning, then at least I'll have them for a while and I'll have to lose their attention.

Mary put extra thought into how she was going to introduce a lesson. Mary's creativity in this area was evident and caused many of the preservice teachers to look to her for ideas.

Second, Mary realized that getting the students' attention was not enough. The problems had to be intellectually challenging and personally useful. Mary felt her ability to gain the students' interest was one of her strengths as a teacher. One way she tried to do this was to make her examples practical. Examples besides the pizza problem included the problem already mentioned about whether the student had a high enough grade to go to Chicago, and a problem to decide which way a student should purchase some compact disks, individually or in packs of three. Mary expressed how she felt her teaching had developed during the quarter when the students considered her "the fun person." She believed this helped her maintain the students' attention, saying:

Then when I had to teach something like solving Algebra I story problems, which, number one, people aren't supposed to like, they see me and it's like they are conditioned to think it will be fun and they do have fun.
Mary's ability to challenge students in a fun way was a positive aspect of her teaching.

One final method Mary used to maintain the students' interest was to personalize the problems she posed, either inserting herself or the students into the problem. This technique was introduced in the methods course during the first quarter, and confirmed by the general methods course during the second quarter. Having the technique supported by psychological theory helped solidify her belief in this practice.

Mary agreed with the use of manipulatives in order to help students visualize concepts in a different way and to engage the students' interest. The theory for their use was reinforced by the general methods course. However, this was another instance in which the cooperating teacher was looking to Mary to model their use for her. Mary felt comfortable using them, but admitted that their use in one lesson was an afterthought, albeit an effective one. In the lesson on equivalent fractions, Mary utilized the Hersheys chocolate bar to introduce the concept and did several textbook-like questions using a package of Smarties, a disk-like candy. The students paid close attention at the beginning of the lesson, but lost some interest when using the Smarties. The questions were routine and Mary chose to give the students a strategy to solve the problem using the Smarties, instead of letting the students develop their own methods of solution. The university supervisor mentioned her concerns about how the candies were used in her interview, but had not mentioned it to Mary. She was not sure the students made the connection between the problem and the manipulative. That connection may not have been well thought-out since Mary had decided to use them on her way into school.
This was not true in the case of the tangrams. In that situation, students were allowed to explore potential solutions using the puzzle pieces on their own and in small groups. That experience afforded the students the opportunity to communicate with one another while using the manipulatives. This use contrasted with the use of the Smarties, since in that instance, Mary was conducting a full-class discussion, doing routine exercises to practice a mathematics skill. The effectiveness of manipulatives as a tool to enhance discussions comes when students are engaged in problem solving that requires them to communicate their ideas using the manipulatives. This distinction caused Mary some confusion, which was reflected in a comment she made about using manipulatives in relation to what was being said during the mathematics seminars:

You think that you have to use manipulatives and say you can do something good. I'd feel guilty if I just had the chalkboard and [the other preservice teachers] are like that's not right. As long as it's interesting, we can be at the chalkboard.

Mary reacted to the mandate of using manipulatives without necessarily seeing how they impacted discussions.

The major form of technology Mary utilized during the second quarter field experience was calculators. This was a tool newly introduced into the cooperating teacher's class and used mainly as a computational device. In one lesson on division of decimals, the cooperating teacher showed the students how to do the problems. Then the students had to do the next five problems without the calculator. Afterwards, the students could use the calculator. When Mary helped the students find the greatest common factor and least common multiple, the students were allowed to use the calculators to check to see if a number was a factor or not.
The final task Mary learned about in the methods course during the first quarter was journal writing. Although not a major factor in Mary's or the cooperating teacher's lessons, both utilized having students write to communicate their ideas. In many of Mary's lesson plans, part of the evaluation required students to write about their understanding of the concept or about how their group had solved the problems. This indicated that Mary's enthusiasm for journal writing expressed in the first quarter was genuine and that she will use this technique to enhance student communication in her classes.

**Category 6: Teacher Intervention in Problem Solving**

This aspect of Mary's beliefs remained virtually unchanged during the second quarter. Mary continued to utilize simpler examples to help students transfer their understanding to a more complex problem with which they were having problems. In one journal entry Mary recounted an experience that reminded her of what she did in junior and senior high school. She had the student replace the numbers in the problem with whole numbers, substituted the student's name into the problem, and asked the student to solve the problem. After the student successfully solved that problem, Mary asked the student to read the word problem again. The student reacted with an exclamation of revelation.

When students proposed incorrect or incomplete responses, Mary showed how the response led to a faulty conclusion. The university supervisor described this behavior:

Mary used to give counterexamples when a student either had the wrong answer or asked a question. She would give a counterexample to get the student to think and to come up with their own solution.
This practice was accepting of the students' ideas and allowed the students to see the error of their own thinking.

The practice of giving hints was a behavior Mary began to reflect on during the second quarter. In her journal writings and during the interview, Mary noted a tendency to give more of a hint than she thought necessary. Mary noted in her tangrams lesson that she possibly had given more hints to "strugglers" trying to solve the puzzles in the second class than in the first. In her interview, Mary explained that her strategy for giving hints in those situations was to make the hints progressively more helpful. During the interview, Mary critiqued an excerpt of her lesson on equivalent fractions. In the beginning of the lesson, she had a student at the board trying to demonstrate that a pizza sliced in eight or a pizza sliced in six slices had the same amount of pizza. She said:

When Darshawn came up to show me and when he drew [a picture] I shouldn't have prompted him so soon like do you want to draw another exactly the same size pizza? That was quite a big hint [laughing to herself]. I should have let him stumble and maybe he could have just drawn one and I'd say I'm still not convinced. Thanks, but I need someone else maybe, and then had someone else so they would have actually drawn it.

Mary saw the benefit of letting a student struggle and drawing other students into the discussion to enrich the discussion. Mary identified time as a factor in the extent to which she gave hints to the students.

Mary continued to indicate that she would never just tell students the answer. The cooperating teacher confirmed that practice, indicating Mary questioned the students if they were stuck until the they came to the correct conclusion or to a point where the students could continue on themselves. Mary talked about not letting students quit after they had come to the board to
do a problem and could not complete the problem on their own. Mary commented:

When I brought someone to the chalkboard and he wanted to sit down because he realized that he couldn't do it after he got up there, I said "No, no, no." I wasn't going to let him sit down without showing him you can do this. And I try to make people successful, you know, because if you're successful, then you're going to want to talk again.

Mary wanted to talk students through problems so they experienced some success, making them more likely to get involved in discussions in the future.

**Category 7: Orchestrating Discussions**

Mary's frequent opportunities to teach in the seventh grade helped reveal how Mary interpreted the suggestions made by the methods course and how she had integrated them into her own beliefs system. Mary expressed beliefs and exhibited behaviors indicating she was somewhere between the extremes of a teacher-centered and a student-centered classroom. Having already expressed the desire to move away from discussions dominated by teacher lectures, she was in the process of determining how far she was willing to move toward having the teacher guide students as they explore and discuss concepts.

Several of Mary's behaviors confirmed her expressed beliefs of having students explore concepts. Her tangram activity exhibited many characteristics of a student-centered class. The students were presented with a problem and allowed to work cooperatively on the problem. She felt the activity exemplified the *Standards* by allowing students to make conjectures, verify the results, and report back to the class. Mary organized other problem-solving activities in large groups in which the class worked together, but
Mary allowed the class to explore avenues of its choosing, often solving problems posed by the students.

In contrast to these behaviors was Mary's tendency to be the central focus of class discussions. This behavior actualized one of Mary's objectives for the mathematics field experiences she identified at the beginning of the second quarter. She wrote:

I'd like to feel comfortable in "controlling" an entire class. Not that I'm the only one talking, but that they respect me and I can conduct a lesson.

Mary's technique of questioning students until they were able to come up with an answer meant that most interactions in class discussions went through her. During one lesson when she felt the students were not paying attention, Mary had the students all turn their desks to face her. In this way she could better control their involvement in the lesson. Having the students involved in the lesson was good, but this also meant that involvement meant following the teacher, not necessarily exploring their own ideas.

As previously mentioned, the university supervisor commented that Mary was possibly talking too much during discussions. Unfortunately, this comment came at the end of the quarter and insufficient time was available to see how Mary would adjust her teaching to incorporate the suggestion. However, comments made by Mary indicated she was not sure she would make a change. In the mathematics seminar Mary shared her beliefs about the contrasting discussion modes.

And a lecture can be exciting too. You know I talk about the circus. Sometimes small group works and sometimes it takes us a lot of time and it doesn't do that much at all. I did this thing on problem solving and the whole time it kind of looked like a lecture, because I was up at the board, and I did problems with their names in them. They said could we do this tomorrow. It was algebra with one variable. Sometimes I
think I can't stand up there and stay at the chalkboard, because that means I'm lazy and can't think of anything better. These comments indicated Mary had not resolved her role in discussion. She said during the final interview she was not convinced about the "rule" of having students talk more. She said, "Just because I talk more, I don't think necessarily that was bad."

This could be the case, but at this point in her development, Mary had not had the time to process the nuances of who should talk and when in discussions. Mary's cooperating teacher's professed main form of discussion was the lecture and that she was looking toward Mary to model new teaching methods for her. The university supervisor's comments identified a potential problem, but did not clarify those times when it was good for Mary to be talking and those times when she could profit from students talking. Without clear instruction in this area, Mary did not want to deviate from a method she felt obtained and kept the attention of the students and was successful.

Summary of Mary's Beliefs and Behaviors About Her Role in Discussion After the Second Quarter

Mary entered the mathematics education program with the intention of doing something different in the mathematics classroom. She wanted to make mathematics exciting and fun for students to learn. The mathematics methods course in the first quarter introduced her to techniques and ideas she felt would enable her to attain her goal. The second quarter gave Mary the opportunity to experiment with the newly-learned techniques and see how they fit in with the rest of her beliefs about teaching mathematics, in general, and conducting discussions, in particular.
Two factors that usually contribute to that development, input by the cooperating teacher and the university supervisor, had less impact than normal. Although the cooperating teacher effectively modeled classroom-management techniques for Mary, she had less influence on Mary's teaching techniques in conducting discussions, because she was in the process of trying to change her own teaching to reflect more of the suggestions made in the Standards. The university supervisor made frequent comments about Mary's teaching, but Mary felt they were too general for her to incorporate them very well into her teaching. Without the opportunity to discuss the comments at any length, their impact was minimal. This meant the majority of the development taking place in Mary's teaching was based on her ability to observe and adjust her own behavior. Mary proved to be very reflective about her own teaching and noted she often did not practice what she thought was best. She developed some definite patterns in her teaching, not all of which reflected the Standards, a fact Mary was convinced was not all bad.

The following sections summarize Mary's development in the seven categories as of the end of her second quarter.

Flow of Ideas. Mary believed in having students come up with their own ideas. The actualization of this belief depended, however, on the objective of the lesson. In problem-solving situations, Mary was flexible in pursuing students' ideas. She explored students' ideas to solve and pose problems on several occasions. However, when the objective involved the mastering of a particular skill, such as finding the greatest common divisor, Mary became more directive and wanted to drive home the concept.
**Student/Student and Teacher/Student Interactions.** When leading the class in discussions, three interaction patterns emerged. Mary utilized small groups to generate interstudent discussion during which time Mary acted as a facilitator while students worked on the problems. Her behavior in those situations reflected what she had been taught in the methods course. When working with the whole class, Mary believed in guiding the discussion through questioning. When solving a problem or exploring a concept, the questioning was more open-ended, with her asking students to propose and justify ideas. If a particular concept was involved, Mary began to ask more factual questions to drive home the concept. These segments of discussion were very teacher-centered with Mary doing most of the talking. Responses were usually no more than a few words, often repeated by Mary and augmented for the class.

**Students Justify Their Ideas.** Mary wanted students to understand the why, not just the how. An answer alone was not a sufficient goal for the students. Her lessons stressed the reasons why rules worked, not only the memorization of the rule, as exemplified by her efforts to help students see that multiplying the numerator and denominator by the same number was essentially the same as multiplying by one, therefore leaving the value of the fraction unchanged. Although Mary asked various types of questions to elicit students' thinking, the students sometimes responded with the accepted rule and not explaining what they thought.

**Acceptance of Ideas.** Mary created an environment in which students were eager to participate. This was due largely to Mary's belief in accepting students' ideas. She often exploited students' ideas by taking them to some logical end before making any judgment as to their correctness. She allowed
students to pose and respond to questions beyond the scope of the prepared lesson. Mary often asked students to vote on the reasonableness of another student's idea. Mary did not always exhibit these behaviors, but she was able to evaluate her own behavior and pick out instances where she could have allowed for more exploitation of students' ideas.

Tasks That Promote Discussion. Mary was able to incorporate most of the tasks proposed in the methods course in the first quarter into the second-quarter field experience. The biggest impact was seen in her use of problems to introduce lessons. Mary believed in getting students' attention early in the lesson with interesting problems or activities. Every lesson she prepared used problems in that manner. Mary maintained the students' interest by personalizing the problems for the students and making them practical, two methods she saw in the first quarter. Mary utilized manipulatives on several occasions, but with less confidence than with utilizing problems. Her tangrams lesson went well, but Mary had a hard time making the connection between the Smarties and equivalent fractions. Mary's belief in journal writing was illustrated in her lesson plans, which often called for some form of student writing. Calculators were utilized, but mostly for computation, having little impact on the discussions.

Teacher Intervention in Problem Solving. This area of Mary's beliefs and behaviors in discussions remained unchanged. Mary continued to give simpler examples, counterexamples, and hints to help students overcome obstacles while working on problems. Mary was attentive to her tendency to give too many or too pointed hints, making mention of that in her journal writings and during her interview. She made a point of continuing to ask questions of students who were stuck until they came up with an answer in
order to build their confidence and make them want to continue to participate in class discussions.

**Orchestrating Discussions.** Mary believed in the teacher conducting discussions that were student-centered, as suggested by the Standards. However, Mary's behavior reflected discussions that were more teacher-centered, in which Mary did most of the talking, usually in the form of questioning. Depending on the circumstances, Mary's questions allowed for more or less input by the students. She was not convinced lecturing or teacher-centered discussions were bad. She felt they could be exciting too, as evidenced by the reaction of the students to many of her lessons where she did most of the talking. The dissonance between Mary's belief of having student-centered discussions and her behavior that often was teacher-centered was not addressed until the end of the quarter, too late for Mary to try different approaches.

In conclusion, the opportunity to teach during the field experiences of the second quarter allowed Mary to develop some teaching patterns that were the result of her interpretation of the techniques presented in the methods course during the first quarter. The mathematics seminar and general methods class had only peripheral influence on the development of these beliefs. Mary's expressed beliefs reflected the Standards in principle, and many of the behaviors Mary exhibited confirmed those beliefs. However, Mary's basic mode of conducting discussion tended toward using problems to get the attention of the students, and then using teacher-centered questioning at various levels to get the students to learn the concepts designated by the curriculum. Mary encouraged students to participate and created an atmosphere in which students were safe to do so. Factors that prevented
Mary from developing a mode of teaching even more student-centered were time and the necessity to convey a certain curriculum.
CHAPTER IX
CROSS-CASE ANALYSIS

The cross-case analysis is reported for the three points in time at which the individual analyses were done: at entry into the program, at the end of the first quarter, and at the end of the second quarter. Just as each individual had different experiences and interpretations of those experiences coming into the program, each preservice teacher had different experiences and interpretations of those experiences in the first and second quarters, despite having a common methods course and a common agenda for the field experiences and the general methods course.

Incoming Preconceptions and Experiences

All the preservice teachers entered the program with excellent academic backgrounds, each carrying an overall G.P.A. of over 3.4, and a G.P.A. in mathematics over 3.5, with the exception of John, who had a 3.2 G.P.A. in mathematics. Each of the preservice teachers considered themselves to be among the better mathematics students in high school, with two of the four taking calculus in their senior years of high school. They each shared some form of tutoring experience in which they shared their expertise in mathematics with less knowledgeable students.
The preservice teachers described mathematics classroom experiences that were predominantly teacher-centered. In this respect their experiences were the similar. The mathematics classrooms described were similar to those described by Goodlad (1984) in which the teacher goes over the homework from the day before, introduces the new lesson, does some examples, and assigns the next nights homework from the textbook.

Table 1 provides a breakdown of the experiences the preservice teachers had according to the seven categories used in analyzing the cases. The picture that emerged was a classroom in which the teacher presented the information in a lecture format. The interactions that took place in the classes were predominantly between the teacher and the students with little student/student interaction. None of the students reported having experienced learning in small groups in which they explored solutions to problem situations, discussing and debating their individual ideas. Students were rarely asked to justify their answers, and ideas were judged by the teacher for their correctness. The purpose of most of the discussion was to establish the correctness of students' answers based on accepted methods taught in the class. The source of most tasks demanded of the students was the textbook. The preservice teachers reported rare instances of utilizing technology, problem solving, or innovative tasks to engage students' thinking. The general methods used by their teachers to intervene when students encountered obstacles in understanding mathematical concepts included giving hints, referring back to simpler problems, providing examples, and modeling how to do problems.

Of the four preservice teachers, only David expressed a strong sense of identity with his senior high school teacher as his role model and motivator.
Table 2. Preservice teachers' preconceptions about their role in discussion when they entered the program.

<table>
<thead>
<tr>
<th>Category</th>
<th>Student</th>
<th>Experience</th>
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<td>Category 1: Flow of Ideas.</td>
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<td>Teacher was the source of</td>
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<td>Would start lessons by giving</td>
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<td>information.</td>
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<td>the basic facts. Desired to</td>
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<td>the ideas initiated by the</td>
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<td>Would do the same. He knew the</td>
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<td>let students learn for</td>
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<td>centered classroom.</td>
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<td>students are valued.</td>
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<td>Category 2: Student/</td>
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<td>The teacher was the central</td>
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<td>Willing to use small groups for</td>
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<td>Desired to move away from this</td>
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<td>Student &amp; Teacher/</td>
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<td>figure of discussions. Student/</td>
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<td>problem solving but not math</td>
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<td>Student Interactions.</td>
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<td>student interactions were limited</td>
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<td>procedures. Would utilize</td>
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<td>interstudent interactions by</td>
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<td>to when students put problems on</td>
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<td>teacher-centered methods of</td>
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<td>utilizing cooperative-learning</td>
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<td>the board.</td>
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<td>his former teachers.</td>
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<td>groups to solve problems.</td>
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<td>David pictured himself acting in</td>
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<td>Math classes involved mostly</td>
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<td>Teachers led students to desired</td>
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<td>teacher/student interactions.</td>
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<td>responses with little student/</td>
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<td>interact more with each other in</td>
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<td>Infrequently given the</td>
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<td>student interaction.</td>
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<td>cooperative settings. Expected</td>
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<td>her students to demonstrate</td>
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Table 2. Continued. Preservice teachers' preconceptions about their role in discussion when they entered the program.

<table>
<thead>
<tr>
<th>Student</th>
<th>David</th>
<th>John</th>
<th>Mary</th>
<th>Rebecah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Experience</td>
<td>Belief</td>
<td>Experience</td>
<td>Belief</td>
</tr>
<tr>
<td>Category 3: Students Justify Their Ideas.</td>
<td>Teachers did not usually ask students to justify answers.</td>
<td>Having students justify their answers was important to David in order to assess students' grasp of a concept.</td>
<td>Former teachers believed students needed to express their grasp of concepts verbally.</td>
<td>An important part of his learning style, John believed he would have his students justify their ideas.</td>
</tr>
<tr>
<td>Category 4: Acceptance of Ideas.</td>
<td>Teachers accepted alternative methods of solution in recitation after ideas were presented. Redirected students back to accepted methods of solution.</td>
<td>Would operate in a similar manner, making sure students answers were logical in the context of the topic.</td>
<td>Teachers placed a premium on the correctness of students' answers.</td>
<td>Indicated he would be accepting of students' ideas and appreciated students' creativity. Would steer students toward the preferred method expressed in the curriculum.</td>
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</tbody>
</table>
Table 2. Continued. Preservice teachers' preconceptions about their role in discussion when they entered the program.

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<td><strong>Category 5: Tasks to Promote Discussion.</strong></td>
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<tr>
<td>David</td>
<td>Teachers exhibited the routine of lecture/recitation format like his math classes.</td>
<td>Expressed openness to the possibility of using &quot;attention getters&quot; to introduce concepts.</td>
<td>Few experiences with tasks to promote discussion.</td>
<td>Expressed a hierarchy in choosing tasks. Tasks were not chosen to promote discussion, discussion depended on the task.</td>
<td>Textbook was the principal source of tasks assigned in math class.</td>
<td>Would challenge the students with non-routine problems, use student journals, and personalize problems.</td>
<td>Teachers used set routines whose goal was to find the &quot;right&quot; answer.</td>
<td>Anticipated learning new ideas in the methods class and was already thinking about using manipulatives in class.</td>
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<td>John</td>
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<td>Rebekah</td>
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**Category 6: Teacher Intervention in Problem Solving.**

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<th>Students</th>
<th>Experience</th>
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<th>Belief</th>
<th>Experience</th>
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<tbody>
<tr>
<td>David</td>
<td>Teachers asked questions, had students refer back to similar problems, or gave the first step in the solution.</td>
<td>Would help students in the same way as his teachers by giving hints or walking them through the problem.</td>
<td>Believed just giving students answers was not appropriate. Preferred to give hints to stimulate thinking.</td>
<td>Teachers provided simpler examples for the students, gave hints to the students, and modeled solutions for students.</td>
<td>Would imitate her previous teachers' behaviors. Would let students struggle with a problem on their own.</td>
<td>Advocated the Socratic Method of leading students through a problem.</td>
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<td>John</td>
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<td>Rebekah</td>
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</table>
Table 2. Continued. Preservice teachers' preconceptions about their role in discussion when they entered the program.

<table>
<thead>
<tr>
<th>Student</th>
<th>Experience</th>
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<tbody>
<tr>
<td>Category 7: Teacher Orchestrates Discussion.</td>
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<tr>
<td>David</td>
<td>Talk in David's classes was clearly teacher-centered. Lecture was the mode of transmitting concepts.</td>
<td>Would model this type of behavior in the classroom for lack of other models.</td>
</tr>
<tr>
<td>John</td>
<td>Teachers showed students what to do. Led students through leading questions.</td>
<td>Would teach like his own teachers; show first, then lead students through leading questions. Saw himself as a fill in the blank man.</td>
</tr>
<tr>
<td>Mary</td>
<td>Classes generally followed the homework, lecture, examples format.</td>
<td>Would deviate from this pattern to make mathematics class more exciting, but not sure how she would accomplish that goal.</td>
</tr>
<tr>
<td>Rebekah</td>
<td>Teachers basically lectured.</td>
<td>Would engage students in questioning to see what they knew. Felt comfortable about being in front of a class and leading discussions.</td>
</tr>
</tbody>
</table>
for becoming a mathematics teacher. This may have been true because he came from a smaller school district and had the same teacher for mathematics during the final three years of high school. He was also able to build a friendship bond with the teacher, a bond that still existed at the time of the study. Mary attended school in a small school district from her freshman to junior years, but was unfavorably impressed her teacher. It was not until her senior year that she had what she considered a positive role model as a mathematics teacher, a factor she cited as contributing to her decision to go into mathematics education. John and Rebekah came from larger school districts and had different teachers almost every year, making it more difficult to identify with any one particular teacher as a role model.

Two preservice teachers, David and John, expressed the overall intention to teach in a manner similar to their teachers'. They had learned well, were sure of their mathematical abilities, and were confident they could teach mathematics as they had been taught. Mary and Rebekah, however, expressed dissatisfaction with the way they had been taught and believed they would deviate from the manner in which their teachers had conducted discussions. Mary desired to make the learning experience more exciting for the students. Rebekah was more reflective about the learning experience and wanted to develop in her students an appreciation for the reasonableness of mathematics. They both had identified a part of the educational system they felt could be improved by their enthusiasm and dedication.

With respect to flow of ideas, David and John believed they would introduce and give the students the basic facts. David verbalized his belief that he was the person who would be "in charge," while John balanced his belief about giving the students the facts with the desire to let students learn
for themselves. On the other hand, both Mary and Rebekah envisioned classes that were more student-centered in which ideas came more naturally from students. Rebekah desire to do this was due to a negative reaction to her own experiences. Mary's desire stemmed from more positive responses to some of her former teachers and ideas she had heard in the mathematics methods classes only in the first week of the quarter.

At the time of his entry into the mathematics education program, David was willing to try classroom interactions that deviated from the teacher/student pattern of interaction exhibited by his high school teacher, but was unsure of how he would do it. John's picture of classroom interactions contained elements of both teacher/student and student/student patterns of interactions. He was willing to let students work in groups, but did not think groups could be used when teaching mathematics skills. Mary and Rebekah wanted to promote more student/student interactions in their classrooms, usually through using small groups to allow students to debate ideas. Although all the preservice teachers were willing to utilize small groups in instruction for the purpose of promoting interstudent interactions, all expressed some reservations about the inability of students to stay on task in small groups and about the group's possibly allowing one person do all the work.

All the preservice teachers wanted their students to justify their ideas in mathematics class. John identified this as being an important part of his learning style and something his former teachers had encouraged. Being able to verbalize one's understanding of a mathematical concept to another person indicated the depth of that understanding. Rebekah felt that by
having students explain themselves, the teacher would be better able to evaluate students' understanding.

Both David and John believed it was important to accept students' ideas, not in order to create a classroom atmosphere in which the correctness of ideas is based on the collective understanding of the class, but in order to be sensitive to the students' feelings. Both expressed the intention to redirect students toward the correct or suggested methods of answering problems if the students were wrong. Mary was sensitive to students' feelings as well, but expressed the desire to demonstrate that the teacher was not the only one with correct answers or the sole possessor of mathematical knowledge. Rebekah also wanted to deviate from a classroom in which one method was considered the "correct" method and other methods were tolerated but not encouraged. She would encourage all ideas that could be justified by the students and wanted to create a classroom environment in which students could freely contribute without being afraid of mathematics.

Without having experienced tasks that promoted discussion in their secondary school mathematics experiences, each of the preservice teachers was looking for ideas that would make discussions more interesting. Each had identified problem solving as a means to achieve this end. David thought about using "attention getters" to stimulate student thinking, as his science teachers had done. Mary intended to personalize problems as a means of stimulating student interest and participation. John had a hierarchy of tasks for discussion. Challenging problems could be done in small groups, thus encouraging student interaction, but simple procedural tasks would be done individually. Rebekah already had picked up some ideas in the first
week of the methods course, including the use of manipulatives to promote discussion.

All the students recognized that just giving the answer to students who were stuck on a problem was inappropriate teacher behavior. This was the one category in which all the preservice teachers felt they would follow what their own teachers had done. This included mainly giving hints, walking the students through a problem together, and sometimes letting the students struggle on their own. Rebekah identified Socratic dialogue as an effective way to lead the students to see what they really understand without the teacher giving the answer.

David and John believed they would orchestrate discussions in the ways similar to their former teachers. David's description of what his class would look like resembled Goodlad's picture the most with David in front of rows of students introducing a topic, doing examples, and asking questions. John's image deviated some from that picture in that would he would guide students through a series of leading questions, but still model what his teachers had done. Mary wanted to deviate more radically from that picture, but was not sure exactly how she would do that. She believed introducing lessons with exciting problems would engage students more in the class' activities. Rebekah described herself as a facilitator, hoping to circulate around the room, engaging students in Socratic dialogue when they were stuck.

Despite the common experiences the preservice teachers had with respect to the manner in which discussions were conducted and the success they experienced as a result of those experiences, these preservice teachers assimilated the experiences in somewhat different ways. Of interest at this
first level of comparison was the fact that the women tended to be more ready to deviate from their experiences, wanting to change the system. Although Mary had a more outgoing personality than Rebekah, both were ready to make changes toward a student-centered classroom. John and David were more content with their experiences and were not willing to deviate too far from their experiences early in their development. This raises speculation that learning experiences in the mathematics classroom may be less satisfactory for women, a connection not established in this research study, but one that is consistent with research that asserts that girls often are neglected in the mathematics class.

Beliefs at the End of the First Quarter and the Factors that Impacted the Development of Those Beliefs

The first quarter of the secondary mathematics teacher preparation program was an intense experience for the preservice teachers. They met three times a week for three hours with their methods course instructor and went out into their respective field placements in elementary school classes two other days for three hours each day. Each student was taking mathematics classes for their mathematics requirements during the afternoon, making their schedules very full.

The methods class impacted each individual with respect to the newness of the approaches being recommended by the methods instructor as proposed in the NCTM Standards, the textbook used for the course. Each preservice teacher was active in the course, participating frequently in the discussions held during the classes observed. All the preservice teachers felt the methods instructor modeled the kind of teaching she recommended.

Individual differences appeared in the manner in which the preservice teachers responded to the instruction in the methods course. John expressed
that much of what was proposed, especially with respect to planning lessons, was common sense for him. He had already perceived himself doing much of what was being recommended. David was less open to all the suggestions being made in the course. He resisted the use of having students do journal writing, because he did not like to write and did not want to make his students do something he would not do himself. Rebekah expressed the expectation that the methods course would show her what to do when teaching. She expected teacher preparation to be more prescriptive, telling her what needed to be done and then testing her for it out in the field. She was disappointed when this did not occur, and she had to figure things out more for herself. Mary was very enthusiastic about what the methods class was suggesting. She saw it as the fulfillment of her desires to do things differently from her own experiences in secondary school.

The preservice teachers were placed in two elementary schools in the same suburban school district close to the university. Three of the preservice teachers were placed in second- or third-grade classrooms, and the fourth in a fifth-grade classroom. Each of the cooperating teachers had had preservice teachers before. The three primary classrooms were all set up for group work in the mornings, mainly in order to allow the cooperating teacher to work with reading groups while the rest of the students worked at activity centers, either independently or cooperatively. The fifth-grade class was run in a more traditional manner with students seated at their desks in rows.

Despite the similar setting for the primary classes, the opportunities to teach were extremely different. John, placed in a second-grade class, was able to teach almost immediately, preparing lessons for the small groups and for the entire class. He worked with his cooperating teacher at identifying skills
he needed to develop with respect to conducting discussions. David, placed
in a third-grade class, was able to teach only one lesson to the entire class. The
rest of the time he prepared activities to share with small groups doing
mathematics, or used activities provided by the cooperating teacher. Mary,
also in a third-grade class, taught no full-class lesson during the quarter. This
was an area of concern for her, because she was anxious to jump in there and
teach. Rebekah conducted many discussions with her fifth-grade class, but
only taught three mathematics lessons to the class. The remainder of the
time she directed discussions after watching a news program on educational
television.

Feedback to the preservice teachers varied. John received the most
constructive feedback from the cooperating teacher. She identified specific
behaviors he needed to work on during discussions. Rebekah received
constructive feedback from the cooperating teacher, but mostly on general
aspects of discussion, not specific to developing mathematical concepts. The
cooperating teacher's approach to mathematics was procedural and did not
reflect what Rebekah was being taught in the methods class. Rebekah was
effective at describing those aspects of the cooperating teacher's behavior that
did not conform favorably with the Standards. Mary and David's cooperating
teachers had little opportunity to critique their teaching, although each
modeled teaching that reflected the Standards. None of the preservice
teachers believed the university supervisors had significant impact on their
teaching. Despite regular visits, they limited their feedback to 5-10 minute
critiques of the lessons they observed.

Table 2 provides a picture of the preservice teachers' beliefs after the first
quarter for each of the seven categories and the factors that impacted the
Table 3. Preservice teachers' beliefs about their role in discussion after the first quarter, and factors that impacted changes in those beliefs.

<table>
<thead>
<tr>
<th>Student/Teacher/Student Interaction</th>
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<tr>
<td>Student/Student &amp; Student/Student Interaction</td>
<td>Expressed that in an ideal situation he would want his students to discover. Would still introduce the topic in some way first.</td>
<td>Rethought decision to always introduce topics after exposure to the Standards, technology use, and experiences with creative students.</td>
<td>Small-group activities allowed students to explore. Full-class discussions were teacher-centered presentations of ideas.</td>
<td>Working in small groups in methods class and directing small-group activities in the field experience.</td>
<td>Would be the one who &quot;teaches.&quot; Wanted ideas introduced by the students, using small-groups, playing the role of a student, and research papers.</td>
<td>Methods course emphasis on student-centered classroom, and placement in class where students investigated concepts on their own and in small groups.</td>
<td>Naïve preconceptions about ideas coming from students tempered to include a more active part in guiding how ideas are introduced in a lesson.</td>
<td>Students did not respond as anticipated. Went off in other directions. Misunderstood methods instructors' directive of letting students initiate discussions.</td>
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<tr>
<td>Category 2: Student/Student &amp; Teacher/Student Interaction</td>
<td>Saw how small groups promoted greater student/student interaction. Would use questions to lead students to the answer.</td>
<td>Experiences with small groups in the field and in the methods class.</td>
<td>Wanted to promote more student/student interaction, but interactions in full-class were teacher dominated.</td>
<td>Methods instructor modeled discussions with students leading discussion. Frequent small-group work in field experience.</td>
<td>Accepted techniques of wait time, Socratic dialogue, and asking higher order questions. Would use small groups.</td>
<td>Methods class modeled questioning techniques. No large group teaching in the field experience. Both components reinforced small groups.</td>
<td>Maintained belief in Socratic approach to questioning. Accepted the use of small groups to promote student/student discussions.</td>
<td>Methods class proposed questioning as the primary mode of discussion. Cooperating teacher modeled effective discussion techniques, but not in math.</td>
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Table 3. Continued. Preservice teachers' beliefs about their role in discussion after the first quarter, and factors that impacted changes in those beliefs.

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<tr>
<td>Category 3: Students Justify Their Ideas.</td>
<td>Maintained preconception that it was important for students to understand a concept more than just produce an answer.</td>
<td>Methods class instructor emphasis on the &quot;why&quot; question. Accepted scripted responses to why question by students.</td>
<td>Maintained preconception of having students justify their ideas.</td>
<td>Methods instructor and cooperating teacher stressed the importance of having students justify their answers.</td>
</tr>
<tr>
<td>Category 4: Acceptance of Ideas.</td>
<td>Continued to have the idea that the teacher needed to lead students to the right answers.</td>
<td>Cooperating teacher corrected tendency to say &quot;no&quot; to a student if they had incorrect answers.</td>
<td>John's Preconception of accepting of students ideas based on concern for students self concepts. Would steer them toward the correct answer.</td>
<td>Reinforced by developing habit in field experience through frequent teaching of entire class.</td>
</tr>
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<td>David</td>
<td>Category 5: Tasks to Promote Discussion.</td>
<td>Accepted use of manipulatives and technology to promote discussions.</td>
<td>Introduced by methods course and utilized in the field experience.</td>
<td>Accepted new techniques to promote discussion: manipulatives, calculators, and journal writing.</td>
<td>Introduced by methods class. Experienced the effectiveness of manipulatives in teaching of his own lessons and activities.</td>
<td>Accepted new techniques to promote discussion: manipulatives, small-group problem solving, technology, and journal writing.</td>
<td>Introduced by methods course. Manipulatives impacted the most. Observed their use in elementary school, but questioned use in upper grades.</td>
<td>Accepted the use of manipulatives, problem solving, technology, and student writing to promote discussions.</td>
<td>Expressed confusion about the difference between their use to gain students' interest and conveying a concept. Cooperating teacher did not model their use.</td>
</tr>
<tr>
<td>John</td>
<td>Experiences did not change those patterns of intervention.</td>
<td>Wanted students to try for themselves.</td>
<td>Monitored his own teaching to develop intervention strategies.</td>
<td>Maintained intention to use methods used by former teachers.</td>
<td>Little of her first quarter experiences impacted her beliefs about intervention strategies.</td>
<td>Maintained decision to engage students in a series of questions to help overcome obstacles encountered in solving problems.</td>
<td>No factor observed from the methods class or field experience.</td>
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<td>Mary</td>
<td>Little of her first quarter experiences impacted her beliefs about intervention strategies.</td>
<td>Maintained decision to engage students in a series of questions to help overcome obstacles encountered in solving problems.</td>
<td>No factor observed from the methods class or field experience.</td>
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<td>Teacher</td>
<td>Deviated from intention to model former teachers by engaging students through questioning, not lecturing.</td>
<td>Especially appreciated the methods class instructors ability to lead discussions.</td>
</tr>
<tr>
<td>Orchestrates Discussion</td>
<td>Believed teacher did not have to do all the talking. Practiced wait time, calling on all students, and not repeating students' answers.</td>
<td>Frequent interaction with the cooperating teacher to discuss teaching efforts.</td>
</tr>
<tr>
<td></td>
<td>Accepted student-centered approach that allows students to explore concepts.</td>
<td>Observed this approach by cooperating teacher in the field experience. Made note of ability to exploit teachable moments like methods instructor.</td>
</tr>
<tr>
<td></td>
<td>Wanted to develop the skill of listening to the students' ideas and tailoring her questions and responses to their input.</td>
<td>Cooperating teacher modeled effective discussion techniques observed and recommended by the university supervisor.</td>
</tr>
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maintenance of or change in those beliefs over the course of the quarter. The student-centered approach emphasized by the methods class challenged the preservice teachers to let students explore concepts on their own before the teacher intervenes and tells them what they need to know. All of the preservice teachers were able to accept this premise for successful mathematics teaching and expressed the image of students exploring on their own as an ideal toward which they would strive.

The field experiences helped gauge the depth to which each of the preservice teachers had incorporated that expressed belief into their beliefs system. David acknowledged that although letting students explore was preferred, he still felt obligated to introduce the concept in some way. In one observation, David started out a small-group problem-solving activity by letting the first group work cooperatively, coming up with ideas on its own. He altered that plan to be more directive with the second group, leading the students to the correct answers, not exploiting their intuitive ideas. John believed in letting students explore, but only after having taught the lesson to the whole class. Mary altered her belief of needing to be the one who teaches. The lessons she observed in her field placement illustrated how students were capable of looking for patterns on their own. Rebekah accepted the idea suggested by the methods class and tried to implement it immediately in her classes. However, she envisioned students coming up with the ideas as she had preconceived them in her mind. When students went off in several unpredicted directions, Rebekah was disheartened and confused. She decided to be more directive in guiding students to the ideas as she saw them. The reality of students' independent thinking tempered Rebekah's idealism about
how students could explore concepts on their own. This represented the
clearest case of conflict between expressed beliefs and exhibited behavior.

Questioning was emphasized by the methods instructor as the primary
function of the teacher in discussions. This reinforced the preservice
teachers' view of their role when interacting with students. All the
preservice teachers expressed the intention of using questioning as their
principal mode of interacting with students. The greatest change in the
preservice teachers' beliefs occurred with respect to the types of
student/student interactions that can take place in the classroom. The
introduction of small-group activities to promote between student
discussions was new to all the preservice teachers, and was an activity they all
said they would utilize in their own classrooms. This mode of interaction
was modeled by the method instructor and the cooperating teachers for all of
the preservice teachers except Rebekah. In Mary's case, that was the only
mode of interaction she was able to practice, although she observed her
cooperating teacher conduct occasional full-class discussions. Each preservice
teacher, except Rebekah, was responsible for creating small-group activities.
In most of those activities, students were allowed to work cooperatively.
However, David sometimes approached the small group like a full class,
entering into a teacher-directed questioning mode.

Among the questions emphasized by the methods instructor was the
"why" question. Each of the preservice teachers picked up on this and
expressed the intention of having students justify their ideas, a belief they
maintained from before entering the teacher education program. All of the
cooperating teachers, except Rebekah's, reflected this belief in their teaching.
John's cooperating teacher noted his progress on asking students to justify
their ideas, even though the students' justification became a recitation of an accepted idea, rather than an explanation of what the student thinks. Mary observed her cooperating teacher frequently ask students explain how they arrived at a response, and the cooperating teacher shared how it had taken time for students to become accustomed to being asked that question. Rebekah noticed the lack of importance her cooperating teacher attached to having students justify their answers.

The preservice teachers' ideas about how and by whom ideas were accepted differed. David and John, who both manifested a more teacher-centered approach to teaching, maintained the belief that it was the teacher's role to steer students toward the correct answer. Early in the field experiences, both exhibited the behavior of saying "no" when a student gave an incorrect response. Their respective cooperating teachers pointed out that this behavior discouraged students from offering their ideas in class, and helped the preservice teachers change their pattern of behavior. Both John and David adopted an approach that accepted the students' ideas, but continued to steer them toward the correct answer.

Mary and Rebekah maintained their preconception that the teacher should not be the one with the "right" answers, and that acceptance should be based on reasonableness as determined by the class as a whole. Mary's enthusiasm sometimes overrode her ability to wait for students' answers, negating her expressed belief. Rebekah experienced conflict when she tried to make the acceptance of ideas a class decision and the class decided to accept an idea that was incorrect. She responded to this by taking a more rigorous stance, not allowing the students to "con" her again. Rebekah lacked the expertise at this point to challenge students' ideas without simply insisting on
acceptance of her own. This situation was exacerbated by a lack of feedback and interaction with the university supervisor and cooperating teacher on this point.

The impact most universally affecting the preservice teachers' images of how they would be conducting discussions was made by the introduction of tools that enhance discussion. Manipulatives, problem solving, student writing, and technology, primarily calculators, were heavily emphasized by the methods instructor as tools that help communicate mathematics to students at all grade levels and help encourage discussion. All the preservice teachers were receptive to their use and expressed the intention of using them when appropriate. The use of manipulatives was exhibited by all the cooperating teachers, except Rebekah's. Each preservice teacher was enthusiastic about the use of journal writing with the exception of David.

Each preservice teacher taught lessons that incorporated at least one of the above mentioned tools. David did a lesson using cardboard clocks to teach multiples of five through a problem-solving worksheet. John had perhaps the most significant experience when he redid a lesson that had previously failed, using unifix cubes to teach additive fact families to his third-graders. John mentioned the success of the second lesson several times over the course of the quarter in the methods class, the second interview, and his journal entries. Rebekah utilized unifix cubes to teacher a lesson on average. Mary did several activities that incorporated manipulatives, and frequently referred students back to manipulatives when they had problems with computation.

An underlying theme emerged concerning the use of manipulatives during this time. The preservice teachers were not always sure how
manipulatives modeled concepts and how they could be utilized to allow students to explore concepts. Several observations were made by the preservice teachers. David expressed concern about how to plan manipulative use in his lessons. His use of manipulatives seemed to be intuitive, for example, the time he spontaneously modeled fractions using checkers. Rebekah expressed confusion about the difference between using manipulatives to gain students' interest and conveying a concept. John's used unifix cubes in his lesson on fact families in a prescriptive manner, setting up the cubes in a way to illustrate a fact family, but not letting students utilize the cubes to discover their own fact families. Mary was satisfied with using manipulatives at the elementary school level, but questioned their use in secondary school, especially when students at that level lacked experience with their use. Left unattended, these conflicts could undermine the use of manipulatives in their own teaching. Because this was an elementary school field experience, the other tools were not as prominent, but had the potential of being equally difficult to put into practice.

The preservice teachers' beliefs about teacher intervention when students were experiencing difficulties was minimally impacted by the methods class and field experiences. All the preservice teachers relied on practices they had observed by their former teachers use. Among the practices were illustrating the concept with simpler problems, using counterexamples and nonexamples, referring the students back to prior knowledge, and asking leading questions to direct the student to the correct answer. John described having developed a practice that was new for him, that of letting the students struggle. Instead of intervening with one of the above practices, John learned
that it was also good to let the students struggle to overcome any obstacles on their own.

All the preservice teachers experienced some level of deviation from their original pictures of how they would orchestrate discussions. All the changes were in the direction of having discussion be more student-centered. David saw himself teaching concepts through questioning instead of lecturing. He attributed much of this change to the modeling done by the methods instructor. John realized that the teacher did not have to do as much as he originally envisioned. By developing the techniques of wait time, including all students in discussions, and not repeating answers, John felt he began to do less of the talking in class. Analysis of his lessons indicated, however, that he still dominated most of the conversation, although in a form of recitation, not lecturing. Rebekah was reflective about her own teaching and effectively compared it to the cooperating teachers' practice. Rebekah identified and developed her practice of wait time, listening to students' responses, and working on questioning skills during the quarter. Both the university supervisor and the cooperating teacher noted a tendency for Rebekah to talk more than necessary during lessons. Mary's cooperating teacher often exploited the teachable moment, a practice emphasized by the methods instructor. Despite this growth toward student-centered discussions, there was a tendency for the preservice teachers to dominate the classroom talk, indicating the strong influence of preconceptions about the leadership role of the teacher in discussions. It appeared that leadership meant teacher-dominated not teacher-facilitated.

The greatest impact made on the students' expressed beliefs originated from the methods course instruction. The amount of new ideas, exposure to
related literature, and the modeling by the methods instructor affected the students' ideas about how effective discussions take place in the mathematics class. The field experience gave the students the opportunity to put those expressed beliefs into practice. The lack of processing time for those experiences, with the exception of John, made it difficult for the preservice teachers to see the discrepancies between expressed beliefs that tended toward student-centered discussions and their observed behaviors that exhibited characteristics of teacher-centered discussions.

Beliefs at the End of the Second Quarter and the Factors That Impacted the Development of Those Beliefs

All the preservice teachers expressed that their experiences in the middle-school classes in which they were placed had the greatest impact on the way they conceived their role in discussions. Each preservice teacher was placed in an urban middle school for the 10-week quarter. All the cooperating teachers in the original placements were taking part in an university program to teach inquiry methods in the mathematics classroom. Although one might think this would be an advantage, this situation turned out to be a negative for the preservice teachers.

The cooperating teachers were themselves in a learning stage, and were trying to break habits that had been ingrained by several years of teaching mathematics from a procedural perspective. In two of the placements, John's and Mary's, the cooperating teachers commented that the preservice teachers were modeling behavior they were trying to develop. Mary's teacher shared how she was impressed with Mary's ability to use questioning to get students to come up with responses in instances where she would have just shown the student how to do the problem. John's cooperating teacher spoke of John's extreme patience in working with students, not going on to another
student or telling them the answer, but asking questions until the student was able to come up with an answer. John commented on his cooperating teacher's reluctance to ask the students to justify their answers, a behavior he felt he modeled for the cooperating teacher.

In Rebekah's original placement, the cooperating teacher exhibited such negative behavior that Rebekah felt obligated to report this to the university supervisor and methods instructor, leading eventually to a new placement in a class where each preservice teacher was responsible for a group of students. Although David's teacher was able to use the language of the Standards, David reported that the cooperating teacher never modeled manipulative use during lessons and had no manipulatives available when David tried to prepare lessons.

Not only did this situation provide a lack of modeling for the preservice teachers, but the cooperating teachers were unable to identify behaviors on which the preservice teachers needed to work. In more instances than not, the cooperating teacher complimented the preservice teacher on their lessons, thus reinforcing potential behavior that perpetuated teacher-centered instruction in the mathematics class. The university supervisors picked up on this problem, but not enough time was built into the program for them to counteract the situation. They, too, did not identify behavior exhibited by the preservice teachers that was in conflict with their expressed behavior with respect to the teacher's role in conducting discussions. In a chance observation, an experienced supervisor working with David's cooperating teacher observed one of David's lessons and provided an exemplary observation that underscored the deficiencies in the observations made by his less-experienced counterparts.
One final comparison between the preservice teachers' field experiences involved differences in their organizational structure. John's experience of teaching one hour every day afforded him a more continuous opportunity to teach. He was responsible for an entire unit on geometry. This allowed him to experience more continuity with the students and less ambiguity about his role in the field experience. Rebekah, after having left the first class in which she was placed, also had a more predictable experience due to the organization of the classroom. Her second cooperating teacher organized the class so that on Thursday and Friday of each week, the four preservice teachers, one of whom was Rebekah, would teach two consecutive eighth-grade classes, one on problem solving and the other on a topic mutually agreed upon the week before. These lessons were independent of what the cooperating teacher had covered the first three days of the week. The lessons were developed and delivered by the preservice teachers weekly. This allowed Rebekah to plan lessons in advance, execute them, and evaluate their effectiveness. Mary and David's classes were continuations of the lessons covered earlier in the week by the cooperating teachers. Due to the variability of middle-school schedules and student achievement, topics could rarely be known in advance. David, especially, would come to school and prepare lessons on the spur of the moment. This often forced the preservice teachers to fall back on teaching methods with which they were most comfortable, to their "default" mode of teaching. This usually turned out to be a more teacher-centered approach in which the teacher did most of the talking. David felt he developed the bad habits of relying on the textbook and preparing hastily.
The second quarter experience in the general methods course had little visible impact on the expressed beliefs and observed behavior of the preservice teachers. Each of the preservice teachers expressed that the course was geared more toward elementary-school teachers. The identification of educational theories that supported the mathematics methods course helped solidify the preservice teachers' expressed beliefs in the suggested methods in the Standards. The secondary-school field experiences related to the general methods class, however, did not model the methods recommended in the mathematics methods course. In Rebekah's case, the teacher, a recent graduate from the university acting as an extended substitute teacher, had apparently given up on many of the ideals proposed in the teacher education program to develop a student-centered mathematics classroom.

Table 3 provides a summary of the preservice teachers' beliefs at the end of the second quarter. Each of the preservice teachers had ample opportunity to teach concepts during the field experiences in the second quarter. Observations of those opportunities, together with their journals and interviews with the other participants in the process, provided sufficient information to see if the preservice teachers' expressed beliefs were in harmony with their behavior.

David and John continued to introduce concepts to the students before the students were allowed to investigate them on their own, in spite of their expressed beliefs that ideas should come from the student. These expressed beliefs were in an early stage of development, an evaluation indicated by the fact that their behaviors often contradicted those beliefs. David may have been influenced to teach that way due to the lack of time he had to prepare his lessons on several occasions. John did provide students with opportunities to
Table 4. Preservice teachers' beliefs about their role in discussion after the second quarter, and factors that impacted changes in those beliefs.

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<td>Felt required to introduce concepts to the students before problems could be addressed.</td>
<td>Needed to be the leader in the class. Struggled with discipline in class. Lacked preparation time to do things differently.</td>
<td>Continued to express the desire to have ideas come from the students. Introduced concepts, then let students explore through small-group activities.</td>
<td>Taught class by himself for eight weeks. Habits were formulated and solidified with little feedback from supervisors.</td>
<td>Believed in having students come up with their own ideas. Exhibited this belief in problem-solving situations. Drove home procedural skills.</td>
<td>Actual opportunities to teach revealed difference between expressed belief and behavior. No modeling from cooperating teacher.</td>
</tr>
<tr>
<td>Category 2: Student/Student Interactions.</td>
<td>Teacher asking leading questions was the principal mode of teacher/student interaction. Used questioning to increase student involvement.</td>
<td>Received little feedback from cooperating teacher to change patterns.</td>
<td>Predominant mode of interaction in discussions was recitation-like teacher/student interactions. Used some group activities to promote discussions.</td>
<td>Continued to practice as he had started during the first quarter in full-class discussions.</td>
<td>Used small groups for interstudent interaction, open-ended questions in problem solving, and factual questions to drive home the concept. Did most of the talking.</td>
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<td>Category 3: Students Justify Their Ideas.</td>
<td>Continued to emphasize having students justify their ideas. Used &quot;why&quot; question to elicit predetermined procedural response.</td>
<td>Saw need for students to be conditioned to justifying their ideas. Short-term feedback from doctoral student to open discussion to students left unaddressed.</td>
<td>Continued to hold the importance of having students justify their answers in class. Felt he modeled this importance for the cooperating teacher.</td>
<td>Cooperating teacher was less concerned about this aspect of discussion than John, teaching in a procedural manner.</td>
</tr>
<tr>
<td>Category 4: Acceptance of Ideas.</td>
<td>Accepted students' ideas, but normally redirected discussion back towards a recommended instructional objective through leading questions.</td>
<td>Doctoral student suggested &quot;taken-as-shared&quot; approach to establish meaning in the classroom. Beliefs unchanged from last quarter.</td>
<td>Believed students should feel free to present their own ideas and challenge ideas presented by the teacher.</td>
<td>Teacher/stu dent pattern of interaction established in discussions caused students to perceive teacher as the one with the answers.</td>
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Table 4. Continued. Preservice teachers' beliefs about their role in discussion after the second quarter, and factors that impacted changes in those beliefs.

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<td>Category 7: Teacher Orchestrates Discussion</td>
<td>Not a lecture, but method of questioning remained teacher-centered.</td>
<td>Lack of modeling in the field experience did not stimulate progress towards a student-centered mode of instruction.</td>
<td>Wanted student-centered discussions. Monitored wait time. Repeating and augmenting student answers made discussions teacher-centered.</td>
<td>Own confidence and distributing questions maintained students' attention even though he talked most of the time.</td>
<td>Wanted discussions observed by the cooperating teacher, but not in time to change teaching.</td>
<td>Excess talking observed by the cooperating teacher, but not in time to change teaching.</td>
<td>Expressed the desire for discussions to be student-centered. Practiced listening to students. Asked leading questions.</td>
<td>Realities of students' abilities made Rebekah deviate from ideals.</td>
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be creative, but usually in lessons after he had presented the basic facts to the
students. For example, exercises with manipulatives to perform geometric
transformations came after he had defined transformation and given some
examples illustrating the concept.

Mary and Rebekah expressed the belief that ideas should come from the
students, and exhibited behaviors consistent with that belief. Mary was
willing to investigate student-initiated problems and gave ownership of ideas
to the students who introduced them. Rebekah's task of teaching problem
solving gave her ample freedom to deviate from a rigid curriculum and let
students explore problems on their own.

Despite the demonstrations of behavior that allowed ideas to flow from
the students, both Mary and Rebekah exhibited behaviors in which the flow
was decidedly from the teacher. Both did this when they wanted to get their
point across. Rebekah seemed to take over when her group got bogged down
on a problem, and she began to ask leading questions to get to the answer,
rather than provide more stimulus to regenerate the students' enthusiasm to
investigate the problem further. Rebekah tended to go into this mode more
frequently with her second class, which had been labeled as "slower." That
class had fewer problem-solving experiences, partially due to the cooperating
teacher's emphasis on computational skills. Because students did not always
come up with ideas as she had envisioned them doing, Rebekah reflected her
belief that ideas should come from the students, and believed she needed to
become more involved. This view may be more realistic than the naive
beliefs she had formulated when first entering the program.

Likewise, after introducing concepts with problems and challenging
students to think about concepts, Mary went into teacher-dominated
recitation in which she tried to "drive the concept home." It was in this stage in her teaching that the university supervisor said she was talking too much, a comment that came too late for Mary to process it. More specific feedback at this point would have been beneficial to Mary in order for her to evaluate that behavior and see if it was consistent with the way she intended to have ideas emerge in the classroom.

The basic mode of interaction for all of the preservice teachers was questioning. Each of the preservice teachers entered into that mode from somewhat different perspectives. David and John organized their classes in a more traditional fashion. David used questioning when going over homework and introducing ideas, as well as to get students involved, to discipline students, and to show students what they still didn't know. The metaphor of a tennis match was applied to John's questioning in which John asked a question, the student responded, John assessed the answer and asked another question to direct the student toward the desired answer. This mode of interaction was counterbalanced with group work that allowed students to interact with one another, usually after the concept being taught had already been introduced.

Mary and Rebekah, on the other hand, tended to go into the leading-question mode after having allowed students to work on a problem on their own or in groups. Then in moving toward the desired answer, they began to ask more directive questions of the students. Mary felt that effective questioning was more effective than having students explore on their own given the level of student with whom she was working. This sentiment was echoed by Rebekah who was concerned about groups not having a leader, a role she played in the small groups for which she was responsible. The lack
of modeling and intervention by the supervisors did not permit the preservice teachers to progress toward their goal of having more student interactions and less teacher-directed interactions.

Having students justify their ideas was a point that all of the preservice teachers agreed upon. They manifested that belief by frequently asking the "why" question. They also agreed that it was necessary to indoctrinate students into feeling comfortable with doing that. Many students respond negatively to having to justify their responses, thinking that having the teacher ask them why they believed something meant they had the wrong answer. The idea of getting students used to the practice was discussed in the mathematics seminars and was an idea that all the preservice teachers believed as well as experienced.

One problem observed in the preservice teachers' behavior was related to the "why" question. Although they believed they were asking for students to justify their ideas and demonstrate their understanding of a concept, the preservice teachers asked the questions in a way that provoked student responses that reflected only the accepted justification for a problem, not their own thinking. This was evident in discussions about equivalent fractions. When asked why two fractions were equal, the students responded because they multiplied by the same number on the top and the bottom. This response indicated they knew what they had done, but gave no indication of what their own thinking was about equivalent fractions. This was not brought to the attention of the preservice teachers during the evaluation of their lessons by the cooperating teachers or university supervisors. This was understandable, because the cooperating teachers felt the preservice teachers were modeling the "why" question for them. It would have been difficult to
point out that the "why" question alone does not guarantee that students are being asked to justify their ideas.

Creating an atmosphere in which students feel free to contribute to the discussion and in which ideas are open for discussion, not for judgment, is important. All of the preservice teachers wanted students to know that the teacher was not the only one with the right answers. They wanted students to challenge teachers whenever they presented ideas the students did not understand or could not accept. In addition to this, however, students' ideas need to be received in such a way as to value that idea and give the rest of the class the opportunity to evaluate its merit. Mary and Rebekah displayed behaviors that indicated they held that belief. Mary frequently went with students' ideas in the class, exploring problems posed by the students. She also frequently asked the class to vote on a student's idea. Rebekah accepted students' ideas during the problem-solving sessions and let the remainder of the group discuss the reasonableness of the idea. While John and David accepted students' ideas without judgment, they usually steered the discussion toward the answer they were looking for by asking the student leading questions. In David's case, this was noticed by the doctoral student who visited one of David's lessons. He recommended that David try to get the authority of correctness of responses to be a group consensus. The effect of this one-time observation was not visible in David's later behavior, and he made little reference to it in later contacts.

Several common threads ran through the beliefs and behaviors of the preservice teachers with respect to the choice of tasks to promote discussion. First, all the preservice teachers used manipulatives at some time during the quarter, confirming their acceptance as expressed in the first quarter. This
occurred despite little modeling done by the cooperating teachers and lack of materials in the schools. One problem observed in the preservice teachers' use of manipulatives, however, was the tendency to introduce or illustrate concepts with manipulatives, but not give students the chance to use manipulatives to explore concepts or explain their understanding of concepts. For instance, John had students use geoboards to illustrate quadrilaterals after he had taught the definition of the term. Furthermore, in most circumstances, the preservice teachers passed quickly to the abstract representation of the concept. The emphasis on the abstract form did not encourage students to work with the manipulatives.

Second, problem solving was a priority for all the preservice teachers. Each expressed the belief that problems were a way of engaging the students' intellect and getting their attention. One technique they all applied to attain that goal was to make the problems practical and personal. Each either personalized textbook problems using names of members of the class or created their own problems. Mary was especially creative in doing that. David and Rebekah were also creative in thinking up word problems of interest to the students. This technique was picked up in the mathematics methods course and reinforced in the mathematics seminar. One discrepancy was that Mary and Rebekah tended to open up lessons with the problems, whereas John and David tended to use the problems after concepts had been introduced.

The remaining two techniques focused on in the mathematics methods course were use sparingly during the field experiences. Calculators were used mostly for computation, and only John and Mary had their students do any
journal writing. In both those situations, the cooperating teacher had modeled the use of writing for the preservice teachers.

The preservice teachers' beliefs and behaviors with respect to intervening when students got stuck remained largely unchanged over the course of the second quarter. Behaviors identified for intervening with students included giving hints, challenging the students with counterexamples, referring the student back to a point of prior understanding, giving simpler examples, and entering into a form of Socratic questioning. Under no conditions would the preservice teachers give the students the answers. All the preservice teachers expressed concern for the students' self-images and wanted students to make overcoming roadblocks a positive experience. A second tendency among the preservice teachers was to use loose vocabulary in order to try to explain concepts with which the students were having difficulty. Only David identified behavior he wanted to change. He felt he needed to be careful about focusing his attention on individuals or particular small groups to the exclusion of the rest of the class when obstacles were encountered. This same problem was identified in the first quarter and carried over into the second quarter.

All of the preservice teachers orchestrated discussions in a manner that would be described as teacher-centered. Each preservice teacher was the dominant figure in the classroom, usually displaying that dominance by engaging the students in questioning that was directed toward an end determined by the teacher. Differences occurred along the spectrum on which one extreme was a classroom characterized by teacher lectures and the other was a classroom characterized by student exploration, toward which the individual preservice teachers leaned. Mary and Rebekah leaned more
toward the student-centered classroom based on their tendency to introduce lessons with problems and exploiting students answers. However, Mary acknowledged that she was the central figure in classroom discussions and believed that lectures could be exciting. Based on her enthusiasm and creativity, her lectures probably would be more exciting than most mathematics classes, but this does not mean they would be the most beneficial to the students.

David and John's discussions were more teacher-centered; they almost always began lessons with the teacher doing most of the talking. David felt he did from 70-80% of the talking when a concept was introduced. This reflects the figures given by Flanders (1970) in which he reported that teachers do close to two-thirds of the talking in classes. David's lack of time to prepare lessons in advance affected his ability to prepare more student-centered activities, but he acknowledged that even with time, he would not have deviated far from his behavior. When John was questioning his students, he repeated and augmented answers, contributing to teacher-dominated discussions with John doing most of the talking. John did have many student-centered activities, but only after his teacher-centered presentations. He, too, acknowledged that he was the central figure in the classroom.

Overall, the second quarter produced little change in the preservice teachers' expressed beliefs. The general methods class, the mathematics seminar, and interactions with the university supervisors had little impact on how the preservice teachers developed their teaching techniques. The cooperating teachers almost never modeled teaching behavior the preservice teachers had learned in the mathematics methods course during the first quarter, and two of the cooperating teachers believed the preservice teachers
modeled behaviors they themselves were trying to develop. The greatest impact came from the opportunity to teach on a regular basis in the middle school and try out some of the ideas they had learned in the first quarter. Due to the lack of feedback, the preservice teachers had to actualize the theories they had seen the first quarter on their own, often getting more feedback from the mathematics seminar in which they were able to bounce ideas off of each other.

A ranking of the preservice teachers from least student-centered to the most student-centered can be made. David's behavior reflected the beliefs he had expressed early in the study. He felt he had not changed that drastically over the course of the two quarters. John's teaching progressed quickly in the first quarter, but seemed to reach a plateau in the second quarter, mainly due to the lack of constructive feedback. Rebekah's expressed beliefs were the most student-centered at the beginning of the study, but the realities of the classroom and her inability to predict the way students were going to respond caused her to modify some of her expressed beliefs and move closer to controlling the classroom discussions. Mary exhibited the most consistent harmony between her expressed beliefs and her behaviors. Although many of her behaviors were teacher-centered when conducting discussions, her ability to accept and exploit students' ideas made her class seem the most student-centered. She was also reflective about what she was and was not doing to promote student discussion, a characteristic seen less extensively in Rebekah, and very little in David and John.
CHAPTER X
CONCLUSIONS AND RECOMMENDATIONS

In response to the research questions posed, the following conclusions were found. First, the preservice teachers examined in this study confirmed that the effects of the long hours of learning spent in school prior to entering a teacher education program do influence the beliefs preservice teachers bring to the teacher education program (Lortie, 1975; Ball, 1988a). "Preservice teachers are not a tabulae rasae before they become involved in their formal preparation for teaching" (Brown, Cooney, and Jones; 1990; p.649). The beliefs that preservice teachers have about teaching as they enter the teacher education programs, however, do not always mirror the models of teaching presented by their former teachers (Zeichner and Gore; 1990).

The length of time the preservice teachers spent as students with any one particular teacher did not determine whether the preservice teacher would use the teacher as their role model. David, who had the same teacher for three years, intended to model his high school teacher when he entered the program. Mary, who also had a single teacher for three out of her four high school years, entered the teacher education program wanting to change things, mainly due to her dissatisfaction with that teacher. Only a favorable experience with her mathematics teacher in her senior year provided the motivation to become a mathematics teacher. John and Rebekah had different teachers each of their years as students in secondary school and
described similar experiences in the way their classes were taught, but John was ready to teach in a way similar to his teachers, whereas Rebekah wanted to make a change in the way mathematics classes were taught, including how discussions were conducted.

The predominant model of conducting discussions experienced by the preservice teachers was teacher-centered, characterized by teachers who went over the homework, lectured on new material, and went over examples with the students. Teachers were the source of information that students passively received. Cooperative learning experiences were virtually non-existent. Although all the preservice teachers felt that this model had worked for them, Mary and Rebekah expected to deviate from that model. They felt it did not challenge the student enough, and they expected the teacher education program to provide the skills and knowledge to enable their teaching to become more student-centered.

Despite those expectations, the "default mode" of conducting classroom discussions for all the preservice teachers was closest to a teacher-centered approach. When forced to rely on their instincts, the preservice teachers reverted back to that mode of teaching throughout the duration of the study. David relied on that approach when asked to spontaneously teach lessons in the middle school, John always introduced material in lecture format before allowing students to explore concepts, Rebekah asked leading questions when students were not seeing relationships in the development of a concept, and Mary did most of the talking when a concept was being taught. Little was done in the field experiences and methods courses to make the preservice teachers aware of the tendency for discussions to be predominantly teacher-
centered and to challenge them to identify their beliefs and bring their behavior in line with those beliefs.

Second, the participation in the mathematics methods course and the related field experiences did affect the expressed beliefs of the preservice teachers. The greatest impact in this area was made by their participation in the mathematics methods course (Ball, 1990; Schram et al, 1988). It was during this time that the preservice teachers were indoctrinated to methods of teaching mathematics that differed from their prior experiences. This instruction affected the way in which the preservice teachers perceived their roles in conducting discussions.

Several ideas proposed during the methods instruction had an impact. The exposure to relatively innovative tools to promote discussion made a significant impact on the preservice teachers. They had never been taught with manipulatives and were impressed with the possibility of giving students hands-on materials to illustrate a concept. Even though the methods instructor admitted to "brainwashing" the preservice teachers regarding their importance, the preservice teachers were excited about the possibility of having students use manipulatives. They felt that with something in their hands, students could better verbalize their understanding of concepts embodied by the manipulatives. Technology, especially calculators, journal writing, and problem solving were introduced to make discussions less teacher-centered, and whose effectiveness was supported by research cited by the methods instructor. Each preservice teacher accepted these methods, innovative for them, as appropriate tools to promote student involvement in discussions, and expressed the desire to use them in conducting discussions in their own classes.
The use of small-group cooperative learning was emphasized by the methods instructor. Although none of the preservice teachers had experienced effective small-group learning in their secondary school experiences, each expressed the desire to utilize small groups in their own teaching. Both the mathematics and general methods classes modeled their use throughout the study.

The emphasis on teacher questioning provided an alternative to lecturing that the preservice teachers were able to easily accommodate into their preexisting beliefs. Each preservice teacher had emphasized the importance of having students be able to justify their ideas when the entered the program. After the methods instruction and field experiences, they believed in asking the "why" question in discussions in order to communicate that understanding mathematics is more important than just having the right answer. The mathematics methods instructor introduced discussion techniques to promote more student involvement, the most prominent of which was wait time (Rowe, 1974). Each preservice teacher was aware of this technique and tried to incorporate it into his/her teaching behaviors.

Technology, especially in the form of calculators, was another tool to enhance discussions emphasized by the mathematics methods course. Research was referred to that supported its use, and special sessions were provided to demonstrate possible uses for graphing calculators and educational software, such as the Geometric Supposer. However, with the exception of a couple of lessons, the preservice teachers had little occasion to use these tools in a manner that affected the nature of the discussions, and used calculators mainly as computational devices.
The field experiences contributed to the preservice teachers' expressed beliefs about their role in conducting discussions by providing new models for teaching and reinforcing the models learned about in the methods classes. The extent to which the field experiences affected the preservice teachers' expressed beliefs in this study depended on two factors: the grade level in which the preservice teacher was placed, and the ability of the cooperating teacher to model methods consistent with what the preservice teachers were learning in the methods class. Preservice teachers placed in primary grades experienced classrooms that most closely reflected the recommendations made in the methods classes. Students in these classes usually worked cooperatively or independently while the cooperating teacher worked with reading groups. The preservice teachers in these classrooms were asked to develop learning activities for these small groups, incorporate manipulatives into these activities, and guide students as they explored concepts on their own. The flexibility of the curriculum in the primary classes allowed children to explore concepts at their own pace with less constraints made by a curriculum that had to be covered in a certain time. This differed from the middle school classes in which the necessity to cover a fixed amount of material prohibited preservice teachers from experimenting with the methods suggested by the methods class.

The cooperating teachers in the primary grades modeled behavior consistent with the instruction in the methods class as well. The second- and third-grade classrooms in which three of the preservice teachers were placed in the first quarter more closely reflected the spirit of the methods instruction than the fifth-, sixth-, seventh-, and eighth-grade classes in which the preservice teachers were placed in the first and second quarters. Each
preservice teacher placed in a primary class experienced lessons taught by the cooperating teacher in which students were allowed to explore problems, make conjectures about what they had explored, and communicate their understanding with others. This type of experience was rarely recorded in the middle-school classes, making it more difficult for the preservice teachers to extend their expressed beliefs into practical situations.

Third, harmony between expressed beliefs and observed behavior was not consistent among the preservice teachers studied. Several reasons were identified for this lack of harmony. When the cooperating teacher modeled, identified, and worked on behaviors corresponding to techniques introduced in the mathematics methods course, the preservice teachers' expressed beliefs were reinforced and solidified. For example, in the case of John, the cooperating teacher in the elementary school field experience worked with John to utilize the technique of wait time, a technique he valued and displayed. Another positive instance in which the methods instruction was reinforced was the fact that all the preservice teachers observed or conducted successful small-group learning and teaching at some point in their field experiences, prompting them to modify their beliefs about using small groups and assuaging some of the doubts about their effectiveness.

However, the impact of the methods instruction on the preservice teachers' expressed beliefs was not always reinforced by the field experiences. Some circumstances did not allow the preservice teachers to develop a belief system in which expressed beliefs were consistent with observed behaviors. One circumstance that inhibited this development was the lack of modeling by the cooperating teachers in the classrooms above the primary level. In the five classes above the fifth grade level, the preservice teachers did not observe
mathematics teaching that modeled discussions as envisioned by the Standards. In fact, two of the cooperating teachers agreed that they looked to the preservice teachers to model for them effective behaviors during discussions.

Another circumstance was that the preservice teachers received little feedback with respect to their role in conducting discussions. Preservice teachers like Rebekah, who anticipated prescribed methods of conducting discussions, are confused when they don't receive feedback after attempts at applying recommended methods falter. Some the cooperating teachers were not aware themselves of effective behaviors in conducting discussions in mathematics classes. An example of this involved David's use of the "why" question. Convinced that asking students to justify their answers was important for effective mathematics teaching, David frequently appended the question, "Why?" to students' responses. Although this was consistent with his expressed beliefs, David frequently settled for a repetition of an algorithm or of a previously determined appropriate justification, neither of which enabled David to understand what the student was actually thinking. Neither the cooperating teacher, nor the university supervisor picked up on this behavior, leading David to believe he was having students justify their answers, when in fact he was engaging students in another form of recitation.

Similarly, all the preservice teachers sensed confusion about how to incorporate manipulatives into discussions. They quickly moved into symbolic forms of a concept after having merely illustrated the concept with a manipulative. For example, John used geoboards to illustrate quadrilaterals instead of allowing students to explore the characteristics of quadrilaterals, a behavior that went unnoticed by either the cooperating teacher or the
university supervisor. Rebekah and Mary, in their lessons on equivalent fractions, directed the students toward using the mathematical procedure instead of the manipulatives they had utilized in introducing the lesson. David admitted to not being sure of how to incorporate manipulatives in his lessons and relied on his intuition to guide his practice. Not receiving adequate feedback about using manipulatives to enhance discussions forced the preservice teachers to accommodate their experiences for themselves. Thinking that using manipulatives was sufficient, the gap between preservice teachers' expressed beliefs and observed behavior went unaddressed, and created a situation similar to that described by Ball (1990) in which a teacher believed she was reflecting the recommended teaching, but in fact was not doing so. At the end of the study, the preservice teachers were convinced of the value of manipulatives, but were unsure about how they could be implemented into their teaching.

Another circumstance that influenced the development of a belief system in which expressed beliefs and behaviors were in harmony was the time prior to lessons that the preservice teachers had to prepare lessons, the time allotted to teach lessons, and the time after lessons to analyze the teaching that occurred. In David's case, he was frequently not informed of what he would be teaching in advance and had to hastily prepare lessons for the same day. Because of that situation, David was not able to experiment with many of the innovative teaching methods proposed in the methods class and reverted to his default mode of teacher-centered questioning. David expressed that he felt he had developed bad habits with respect to his choice of tasks and preparation for lessons due to this situation.
Time affected the preservice teachers' ability to experiment with ideas they had seen in the methods class. The students in Rebekah's slower eighth-grade class were already beginning to focus on the proficiency exams that they would have to take in the ninth grade. Because of the need to concentrate on the skills needed to pass those tests, time constraints did not permit her to attempt discussion methods that seemingly required more time, such as problem solving, manipulatives, and small groups.

Finally, sufficient time was not built into the program to allow the preservice teachers to analyze observed lessons with their university supervisors and cooperating teachers and plan strategies to improve the quality of the classroom discussions. Outside of John's cooperating teacher, the preservice teachers felt that few areas involving their role in discussions needing improvement were identified and that they received little constructive criticism from the university supervisors and cooperating teachers.

The mathematics education program observed had the goal of helping preservice teachers create a student-centered classroom environment in which ideas flow from the students; students are given the opportunity to discuss and justify their ideas with one another under the supervision of the teacher; acceptance of ideas is a class determination, not an arbitrary decision by the teacher; tools are utilized to enhance discussions; teachers intervene to promote and challenge students' thinking; and discussions are orchestrated by the teacher by listening to what students are saying and deciding what avenues of discussion are most productive for the class. Although the instruction of the mathematics methods class produced changes in the preservice teachers' expressed beliefs, the lack of coordination with the field
experiences did not allow the preservice teachers to develop belief systems in harmony with that goal. By the end of the second quarter, the preservice teachers had developed teaching behaviors that were mostly teacher-centered, interspersed with occasional attempts to actualize their more student-centered expressed beliefs. However, the lack of feedback, especially in the second quarter, did not enable the preservice teachers to build on those attempts, thus making them fall back into a more teacher-centered approach to teaching. These approaches were similar to the beliefs expressed when entering the program, dominated by teacher/student interactions characterized by questioning that led students to desired answers.

**Implications**

The results of this study have several implications for mathematics teacher education. First, preservice teachers enter the program with preexisting beliefs about what their role in classroom discussions will be. Without intervention to modify those beliefs, preservice teachers would base their teaching on those beliefs. It is, therefore, important to have prior knowledge of what those beliefs are to help the teacher educator organize tasks that help preservice teachers become aware of their own beliefs, as well as challenge or reinforce those beliefs. Without the development of that awareness, preservice teachers will act according to their pre-existing beliefs system.

Second, ideas presented in methods classes impact the expressed beliefs of students. Preservice teachers enter the teacher education program expecting instruction to help them become effective teachers. Methods that affect discussions in the mathematics class are suggested by their instructors are generally accepted and incorporated into their expressed beliefs. However,
opportunities in which preservice teachers are allowed to apply these methods are necessary in order to see how the preservice teachers have assimilated the suggestions into their pre-existing beliefs system. Observed behavior can reveal discrepancies between the intended message of the teacher education program and the interpretations made by the preservice teachers.

Third, the coordination between the methods instruction and the related field experiences is essential to having the preservice teacher develop behaviors that are consistent with the newly expressed beliefs they profess as a result of participation in the methods classes. As evidenced by the placements in the primary grades, field placements should provide a setting in which preservice teachers attempt to implement suggested methods. Supervision by the cooperating teachers and the university supervisors needs to bring inconsistencies in beliefs and behaviors to the attention of the preservice teachers. Preservice teachers tend to assimilate new experiences into their pre-existing belief system, giving them the impression that they are teaching in ways recommended by the methods instruction. Cooperating teachers need to model teaching consistent with the methods taught by the teacher education program. Without close observation and appropriate feedback from their supervisors, the preservice teachers' behavior will only be a dim reflection of the intended behaviors. Field experiences in which preservice teachers do not have ample time to prepare lessons that attempt to implement new discussion methods and do not provide adequate feedback from supervisors may reinforce pre-existing teacher behaviors and be a detriment to developing discussion methods that reflect the Standards.
**Recommendations.**

In order to provide mathematics teacher education programs that foster the development of beliefs and behaviors consistent with the recommendations of the *Standards* with respect to the teacher's role in conducting discussions, the following recommendations are made:

1. Mathematics teacher education programs should assess preservice teachers' beliefs about their role in discussion in the mathematics classroom prior to methods instruction and related field experiences.

2. Mathematics teacher education programs should help students become aware of their expressed beliefs about their role in conducting classroom discussions in order to examine how well their classroom behaviors reflect those beliefs.

3. Field experiences should be planned so that the methods recommended by the teacher education program are appropriately modeled by the cooperating teachers.

4. Cooperating teachers and university supervisors should be aware of the goals of the teacher education program for the development of discussion methods in the mathematics classroom and provide ample time for preservice teachers to analyze observed lessons in order to identify aspects of the preservice teachers' behavior that are not consistent with their expressed beliefs.

The development of teaching methods that are dissonant with or that contradict beliefs developed though years of participation in mathematics classes is not a simple task. The above recommendations form only a modicum of the measures that can help prospective teachers change behaviors ingrained by years of experience. Continued investigation of the
development process is necessary in order to adequately prepare teachers to continue the change process as they enter into the teaching work force.
LIST OF REFERENCES


APPENDIX A

CATEGORIES CLASSIFYING TEACHER'S ROLE IN DISCUSSION
Analysis of the screening questionnaire and responses to questions during the first interview were classified according to the seven categories describing the teacher's role in discussion.

**Category 1: Flow of Ideas.**

The first category recognizes the origins of ideas that are discussed in the classroom, whether by the teacher or by the students. This aspect of discussion impacts the way discussions are perceived by the teacher and students and affects who initiates the discussion and the direction in which it will flow. If classroom practice is established in which the teacher has all the knowledge and that the students are there merely to absorb that knowledge, students will take a passive posture in discussions. Conversely, if classroom practice is established in which students and teachers have valid ideas about mathematical concepts, students will take an active posture in discussion, sharing their ideas on an equal basis with the teacher.

**Category 2: Student/Student and Teacher/Student Interaction.**

Student/student interactions and teacher/student interactions help classify the type of discussions that take place in a class. They can be in small groups or in the class as a whole. The more students are drawn into discussions in which their ideas are respected and analyzed, the more they will listen to each other as ideas are exchanged. If ideas are always processed through the teacher, then students will be more likely to only pay attention to what the teacher is saying, knowing that what the teacher says is what is important in the class.
Category 3: Students Justify Their Ideas.

The Standards emphasize the need for students to be able to justify their ideas. Justification helps the teacher identify what the student is thinking, which in turn provides information to effectively guide instruction. This aspect of classroom talk helps distinguish recitation aimed at getting at the students' factual versus conceptual knowledge.

Category 4: Acceptance of Ideas.

The way in which ideas are treated in the mathematics classroom impacts how students perceive mathematics and their contributions to the class. If student's responses are accepted only on the basis of their correctness as judged by the teacher, students are reluctant to participate in the discussion, only wanting to talk when they have the right answer. Classrooms in which all responses are respected promote more student involvement in the discussion.

Category 5: Tasks that Promote Discussion.

Tasks that engage the students in discussion are those that ask the students to actively explore concepts and communicate their findings with other members of the class. These explorations usually involve a problem that students can investigate using different types of tools, such as manipulatives and technology.

Category 6: Teacher Intervention in Problem Solving

The means by which a teacher intervenes when students reach a point of not being able to continue towards a problem's solution are influential in fostering effective classroom discussion. Teachers that do not intervene with a correct answer, but allow students the time to express their thinking, promote an atmosphere of inquiry in the classroom.
Category 7: Orchestrating the Discussion.

Orchestrating a discussion requires a mixture of the behaviors already identified in Categories 1-6. The extremes of this category provide a way of distinguishing the basic approach that a teacher takes to conducting discussions. That approach can reflect one end of the spectrum and be teacher-centered, where the teacher lectures to students on what they need to know, or be student-centered, where the teacher engages students in tasks that require them to communicate their ideas about mathematical concepts.
APPENDIX B

BELIEFS/EXPERIENCE GRID: FIRST INTERVIEW
Students responses to the screening questionnaire and first interview were put into a grid of experiences and beliefs that were classified as either reflecting the *Teaching Standards* or not.

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<th>Beliefs</th>
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<th>Experiences</th>
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APPENDIX C

EXPERIENCES/BELIEFS PLACEMENT GRID
The following coordinate system represents the placement of the preservice teachers who were potential participants in the case studies. The horizontal axis represents the sum total of the students experiences related to the teacher's role in discussion in the mathematics classroom, as determined by their responses on the questionnaire and during the interviews. The vertical axis represents the sum total of the students beliefs as determined by their responses on the questionnaire and during the interviews. Positive values represent totals that were determined to be more Standards-like and negative totals represent totals that were determined to be more Non-Standards-like. The coordinates are given next to the student number.

- Rebekah: (-15, 14)
- Mary: (-9, 14)
- Kari: (-15, 7)
- Gail: (-15, 6)
- Sally: (-14.1, -14.1)
- Katrina: (-12, 4)
- Erin: (-10, 1)
- John: (-10, -2)
- David: (-11, -6)

Experiences

Beliefs
APPENDIX D
SCREENING QUESTIONNAIRE
Questionnaire: Teacher's Role in Discourse

The role of the teacher in classroom discussions is very important. As a student who has taken many mathematics courses and desires to teach mathematics, your ideas on this subject are important. There are no right or wrong answers to the following questions. They ask only what you've experienced and the ideas you've formulated about classroom talk. Your answers are completely confidential; please feel free to answer the questions, knowing that no one except the researcher will know their source.

The following depict discussions that could take place in a mathematics classroom. Please answer the questions related to each scenario. All questions referring to teachers are assumed to refer to high school or college mathematics teachers from whom you have learned mathematics. Comments and questions about the scenarios appear in the margins. Answer these questions in the spaces provided. When a simple yes or no answer is requested, you are encouraged to supply additional clarification in the box provided. In some of the questions that follow the scenario, a scale from 1 to 10 is used to register your answers. Circle the number on the scale that most accurately describes your answer. For example, a person ranking the response a "7" would circle 7, as indicated below.

1  2  3  4  5  6  7  8  9  10
Scenario I:
Toward the end of a unit on quadratic equations, Mrs. Santos has decided to assess her algebra students' use of problem-solving processes and their ability to make mathematical connections, both among ideas in the unit and between these ideas and concepts covered earlier. To do this, she chooses the following problem:

Find all the values of $x$ for which

$$(x^2 - 5x + 5)x^2 - 9x + 20 = 1.$$
She decides to ask students to work on the problem in pairs while she circulates among as many of the pairs as she can, monitoring their progress. She uses a checklist with students' names on it as an easy means of recording observations about students' thinking, approaches, and patterns of working.

Mrs. Santos has the students working cooperatively in pairs. How often did your teachers have you work cooperatively?

- Daily____
- Several times a week_____ 
- Once a week_____ 
- Once a month_____ 
- Hardly ever____

The first pair of students she visits, Alan and Bettina, groan, "This is really going to be gross!" "Look, it's got two different quadratics in the same equation!" "Yeah, it's not fair. She never gave us such a complicated one before!" "Oh, well," Bettina says, "we might as well get started. Let's factor $x^2 - 9x + 20$ and see what we get." When they find that $(x-4)$ and $(x-5)$ are the factors, Alan says, "Well, I guess that's it, $x=4$ and $x=5$ must be the answers."
Bettina does not seem certain about Alan's assertion. "What about this other quadratic? Don't we have to check that it works there, too?" she asks. "Oh, yeah," agrees Alan, "you check 5 and I'll check 4." So, they substitute 4 and 5 into $x^2 - 5x + 5$ and find that they get 1 for $x=4$ and they get 5 for $x=5$. Alan says, "I get 1 like I'm supposed to," but Bettina says, "I don't get 1, I get 5." This result puzzles them.

As they look at the problem together, Alan says, "We need to use both quadratics together," and Bettina chimes in, "Yeah, it's this to that power." Evaluating the entire expression, they find that for $x=4$ they get $1^0$ and for $x=5$ they get $5^0$. The comment that "it's one either way; anything to the 0 power is 1." Out of the corner of her eye, Mrs. Santos notices a pair of students clowning around by the window. She approaches them and asks, "What's up?"
"No way we can do this problem, Mrs. S," says Diarra. 
"And, besides, who CARES?" adds Tommy. 
Mrs. Santos guesses that part of their frustration is 
that the problem looks too complex. She invites 
them to try the problem by putting in some numbers. 
"How about 1?" suggests Diarra, giggling.

"Yeah," agrees Tommy. 
When they try 1, they are surprised to see that it 
works out. 
"Hey, this is easy, man!" exclaims Tommy. At this, 
other students crowd around. 
Are there other solutions?" asks Mrs. Santos, 
relieved that the students are becoming engaged.

Mrs. Santos provides a hint and expects the students 
to get involved. What did your teachers tend to do 
when you got stuck?
"I'll try 2," volunteers one. Others are trying other numbers. As she walks away, Mrs. Santos hears another burst of excitement as a pair of students discovers that two works and a groan from someone who tried 0.

Mrs. Santos looks around the class for another group to visit and notices another pair, Peter and Ona, lounging with nothing to do. "How are you two doing?" she inquires pleasantly.

"Great!" Peter replies, "We got the answer; it's 4 and 5." They show Mrs. Santos how they did it. They have used an approach similar to the one used by Alan and Bettina.

Mrs. Santos asks, "Didn't you just say that when x=4 you got this polynomial [pointing to the base, ()] to be equal to 1?" She pauses, hoping that they will notice the importance of the base having the value 1.

Mrs. Santos wants to provoke the students to continue looking for solution; so she decides to ask a question that she hopes will challenge their idea that they have finished and extend their thinking about the problem.

How often did your teachers challenge you to justify your answers:

Daily_____
Several times a week_____
Once a week_____ 
Once a month_____ 
Hardly ever_____

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After some consideration, Peter says, "Yes, but we were worried more about the exponent being 0; but if the base is 1, the exponent wouldn't have to be 0."

Ona says, "Okay, let's see if we can solve $x^2-5x+5 = 1$. So they set out to factor the $x^2-5x+5$, ignoring the fact that it is not set equal to 0.

Mrs. Santos glances at her watch and sees that the period is almost over. She decides to end the class by reminding the students to write their journal entries for the day. They are to record the problems and successes they encountered during the period, any new insights, and anything that stood out to them about other students' arguments or solutions in class. (NCTM, 1991, p.42-3)

**Questions on Scenario I:**

For questions 1 and 2, rank your answer on a scale of 1 to 10, with 1 being "never" and 10 being "often."

1. How often have you experienced a classroom similar to this one in high school?

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<th>Often</th>
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2. How often have you experienced a classroom similar to this one in college?

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<th>Never</th>
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3. Identify aspects of the scenario that you've experienced before.
4. Identify aspects of the scenario that you haven't experienced before.

For question 5 and 6, rank your answer on a scale of 1 to 10, with 1 being "minimally effective" and 10 being "extremely effective."

5. How effective was or would have been your learning during classroom experiences similar to this?

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6. How effective was or would be your fellow students' learning during classroom experiences similar to this?

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For question 7 and 8, rank your answer on a scale of 1 to 10, with 1 being "minimally comfortable" and 10 being "extremely comfortable."

7. How comfortable do or would you feel learning in situations similar to this?

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8. How comfortable would you feel teaching in situations similar to this?

<table>
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<th>Minimally</th>
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9. What aspects of this approach would you use as a teacher? Explain.
Scenario II:
Toward the end of a unit on quadratic equations, Mr. Smith has decided to assess his algebra students’ use of problem-solving processes and their ability to make mathematical connections, both among ideas in the unit and between these ideas and concepts covered earlier. To do this, he chooses the following problem:

The length of a rectangle is 3 feet longer than its width. If the area is 130 sq. ft., find the length of the rectangle.

Mr. Smith opens the class by putting the problem on the blackboard, and asks the class to read it silently. Then he begins the discussion by asking: “What’s the first thing that we need to do to solve this problem?”

Have your algebra teachers asked questions like this? If so, what about the question is similar?
Bill, after raising his hand, is acknowledged and responds: "We need to understand the problem." "Good, what can you do to help yourself understand it?" replies Mr. Smith.

"We could make a rectangle that represents the problem information" says John, not raising his hand. "O.K. Come the the board and make a figure, John" asks Mr. Smith. John goes to the board and makes the following figure.

\[
\begin{array}{c}
\text{width} \\
\end{array}
\]

\[
\text{length} = \text{width} + 3
\]

Mr. Smith has decided to engage in a full class discussion and use the problem-solving steps that he has taught the class. How often were your class discussion led by your teacher before the full class?

- Daily_____
- Several times a week_____
- Once a week_____
- Once a month_____
- Hardly ever_____

"We could make a rectangle that represents the problem information" says John, not raising his hand. "O.K. Come the the board and make a figure, John" asks Mr. Smith. John goes to the board and makes the following figure.
Mr. Smith is pleased with the figure and responds; “Good John! Sarah, what do we need to do next?” Sarah, feeling embarrassed, answers; “I don’t know.” Mr. Smith goes on to another student and ask: “Mary?” After a few seconds of thought, Mary responds; “We need to represent the unknowns by a variable.” “Good, Mary. Can you do that?” he asks. “We could let x equal the width of the rectangle and then x+3 would equal the length.” replies Mary. “Well done, Mary.”

Mr. Smith praises students for correct answers. Did your teachers use this practice while teaching? Daily _____ Several times a week______ Once a week______ Once a month______ Hardly ever______

Mr. Smith goes to the board and writes:

Let x = the rectangle's width and x+3 = the rectangle's length
Mr. Smith is pleased with the way the students are responding, following the steps that he has previously outlined for them as steps to solve word problems. He continues the discussion by asking; "What do we do next, Tom?" Tom, whose hand has been up almost the whole time says, "I think the answer is 13 ft." "How did you get that, Tom?" asks Mr. Smith. "I just saw that two numbers that multiply up to 130 are 10 and 13, and that 13 is three more than 10, so it must be the length of the rectangle." "That's good, but how did you apply algebra to get that?" replies Mr. Smith. "I didn't" Tom responds, "I just figured it out."
“Let’s see if we can use algebra to check your answer, Tom” says Mr. Smith. “Can anyone come up with an equation that will represent this problem?” he asks. Mary speaks up and says; “Since the area is 130 sq. ft. and area equals length times width, we can say x times x plus three equals 130.” \[x(x+3) = 130\]. “Very good, Mary” responds Mr. Smith. He writes the equation on the board and tells the class, “Now, each of you solve this equation at your desks, using the techniques that we’ve learned, and when you get an answer, raise your hand so I can come around to check.”

Once the equation has been found, Mr. Smith has the students work at their desks, so he can check their work individually. Was this a common practice in your mathematics classes?

Daily_____
Several times a week_____
Once a week_____
Once a month_____
Hardly ever_____
After several students have shown their answers to Mr. Smith, he addresses the class, reviewing the steps in the problem solving process he's taught the class; “As you can see, Tom was correct. The solutions to the equation are 10 and 13. So, let’s review the steps in solving word problems: (1) understand the problem, using diagrams when appropriate; (2) represent the unknowns using a single variable; (3) write an equation that represents the problem situation; and (4) solve the equation, checking your answer in the word problem.

Is this approach to problem solving similar to or different from the approach used in your mathematics classes? In what way?

Questions on Scenario II:
For question 10 and 11, rank your answer on a scale of 1 to 10, with 1 being "never" and 10 being "often."

10. How often have you experienced a classroom similar to this one in high school?

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<th>Never</th>
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<th>7</th>
<th>8</th>
<th>9</th>
<th>Often</th>
<th>10</th>
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</table>

11. How often have you experienced a classroom similar to this one in college?
   Never                      Often
   1                      2   3   4   5   6   7   8   9   10

12. Identify aspects of the scenario that you've experienced before.

13. Identify aspects of the scenario that you haven't experienced before.

For question 14 and 15, rank your answer on a scale of 1 to 10, with 1 being "minimally effective" and 10 being "extremely effective."

14. How effective was or would be your learning during classroom experiences similar to this?
   Minimally                      Extremely
   1                      2   3   4   5   6   7   8   9   10

15. How effective was or would be your fellow students' learning during classroom experiences similar to this?
   Minimally                      Extremely
   1                      2   3   4   5   6   7   8   9   10

For question 16 and 17, rank your answer on a scale of 1 to 10, with 1 being "minimally comfortable" and 10 being "extremely comfortable."

16. How comfortable do or would you feel learning in situations similar to this?
   Minimally                      Extremely
   1                      2   3   4   5   6   7   8   9   10

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17. How comfortable would you feel teaching in situations similar to this?

Minimally     Extremely

1   2   3   4   5   6   7   8   9   10

18. What aspects of this approach would you use as a teacher? Explain.

Overall Questions:
1. From your experiences up to this point in time, describe the role of the teacher, as you perceive it, in classroom discussion.

2. Of the two scenarios, which one would most likely reflect how you think you would conduct classroom discussion? Explain why.

3. Number of years since my last high school mathematics class.___________

4. Number of mathematics courses beyond calculus._______________

5. At present, I am confident that my mathematics abilities are sufficient to teach mathematics at the:
Jr. High School Level: yes___ no___ not sure____
Sr. High School Level: yes___ no___ not sure____

6. Sex: Female [ ] Male [ ]

7. G.P.A.: Overall [ ] Mathematics [ ]

8. A study of your methods class and field experience participation during the next two quarters will follow the questionnaire that includes three interviews and permission to review journal entries and other related classwork. If you are willing to participate in the study, please check the yes box and fill in your name and phone number. Students who participate will be reimbursed for their time during the interviews.
Are you willing to participate: Yes [ ] No [ ]

If Yes, Name:_________________________________________Phone #_____________________

If you've reached this far, you've done a great job. Thank you very much for your help and cooperation!
First Student Interview

Thank you for being willing to participate in this study. The objective is not to evaluate you in any way, but rather to describe your experiences as a mathematics learner and your beliefs toward the role of the teacher in classroom discussion as you enter the teacher education program. In order to obtain an accurate account of your answers, I will be audiotaping the interview. Would you like to hold the recorder in order to stop the taping for any reason?

Student's answer: ________________________________

Good! Let's begin.

Questions regarding student's mathematics background.

1. You said that you took ___________(Blanks will be replaced by student's answers on the questionnaire.) courses of mathematics in high school. What courses did you take?

2. How many different mathematics teachers did you have during this time?____________________

3. Did any particular teachers influence you more than others in your decision to become a mathematics teacher? ________________

If yes, ask: What was it about that teacher that impressed you the most?

Describe the situations in which teacher/student discussions that took place in their classes?

Describe the situations in which student/student discussions that took place in their classes?

4. You said that you were ___________ about your abilities to teach Jr. High School and Sr. High School. What causes you to have (not have) this confidence? Optional, if the first interview goes too long.
Questions about the student's responses to Scenario 1.
Here is the questionnaire that you filled out. Look over Scenario 1, again.

5. The teacher chose for the students to work in groups. You said that you __________ worked in groups. What would the teacher be doing while the students worked in groups?

In what situations would you have your students work in groups? For what reasons? What would you be doing during this time? What would you expect the students to be doing?

In what situation wouldn't you have your students work in groups? For what reasons?

6. In your secondary school mathematics classes, if you or your group got stuck on some problem, describe what would your teachers tend to do when you asked for help?

As a teacher, what are some of the things you would do if your students got stuck on a problem?

OPTIONAL

7. You rated your learning in similar situations as __________ on a scale of 1 to 10. Why?
8. *You rated the learning of your fellow students in similar situations as ________ on a scale of 1 to 10. Why?*

9. You rated your comfort level in similar learning situations as a ________ on a scale of 1 to 10.
   With what aspects are you comfortable? uncomfortable?

10. You rated your comfort level in teaching in similar situations as a ________ on a scale of 1 to 10.
    With what aspects are you comfortable in using? uncomfortable?

**Questions about the Student's responses to Scenario II:**
Now, please look over Scenario II, again.

11. The teacher decided to engage the students in a full-class discussion. If I had been in your classes, describe what I would have seen the teacher doing during a full-class discussion?

   As a teacher, if you decided to incorporate the whole class in discussion, what would you be doing during the discussion and why would you be doing it? *(You may need to probe here.)*

12. You said that your teachers ________ praised students for correct answers. In your classes, what would your teachers do when students gave incorrect answers? Correct answers?
As a teacher, what would you do in those situations? Why?

13. The teacher in the scenario accepted a student's answer to find and then redirected the discussion back toward the planned method of solution.

Did you ever develop an alternative method to solve a problem?

How did your teacher's respond to your method?

What would you do as the teacher when a student introduced their own method of solution to a problem that differed from the planned methods? Why is that important?

OPTIONAL

14. You rated your learning in similar situations as ___________ on a scale of 1 to 10. Why?

15. You rated the learning of your fellow students in similar situations as ___________ on a scale of 1 to 10. Why?

16. You rated your comfort level in similar learning situations as a ___________ on a scale of 1 to 10.

   With what aspects are you comfortable? uncomfortable?
17. You rated your comfort level in teaching in similar situations as a ________ on a scale of 1 to 10. With what aspects are you comfortable in using? uncomfortable?

18. Describe any opportunities that you have had in which you took the part of a teacher. What would I have seen during any discussions?

19. If you were in your own class today, teaching a class that you feel comfortable with a topic that you are confident about, and I was a fly on the wall, describe what the discussion in your class would sound like. Include who would be talking, in what setting, and towards what objective.

20. Explain how discussion and interactions in the mathematics class are the same or differ from other subjects.

21. What other aspects about the teacher's participation in mathematics classroom discussion not illustrated in these scenarios or in our discussion that you would like to add?

Thank you very much for your time and effort!
Protocol: Second Student Interview

I hope that you have enjoyed your experiences during this first quarter in the mathematics education program. I would like to discuss some of those experiences with you, and the impact that they had on your ideas about teaching mathematics. By discussion we are referring to the thoughtful and organized conversations that take place in the classroom while students form ideas about mathematical concepts. We'll use the same format as in the first interview. Okay? Let's begin.

I. Member check on prior experiences and beliefs.
Here is a picture of how I perceived your learning experiences with respect to the teacher's role in discussion in the mathematics classroom based on the first interview and your responses to the questionnaire.
• Is that picture an accurate account of the experiences that you had prior to when I first interviewed you?

• If not, What aspects of that picture should be changed to better reflect your experiences?

• Which techniques that your former teachers used have you adopted into your own emerging style of teaching? Press them to name at least three and try to probe as to why these techniques have made an impact on them.

• Which techniques that your former teachers used have you not adopted into your own emerging style of teaching? Press them to name at least three and try to probe as to why these techniques have had a negative impact on them.

II. Questions About the Methods Course and Its Impact on the Student's Beliefs and Perceptions About the Teacher's Role in Classroom Discussion.
• What methods of teaching did you learn about in the methods course that related to the way that the teacher would participate in discussion in the mathematics classroom?
  - Ask specifically about questioning techniques taught.
  - Ask about the use of manipulatives, calculators, computers, and other tools that enhance discussion in the classroom.
• How were these methods modeled by the methods instructor?

• How did these methods differ from the picture of how you perceived classroom discussion when you first entered the program?

• How has participating in the methods course changed the way you believe you will be teaching when you get into your own classroom?

• What experiences contributed the most to that change, if perceived?

• What ideas in the methods class with respect to the teacher's role in discussion in the mathematics classroom were you not able to buy into? Why?

• Describe any ah-hah experiences you had with respect to teaching while participating in the methods class. Explore any ramifications these experiences might have with respect to discussion.

III. Questions About the Field Experience and Its Impact on the Student's Beliefs and Perceptions About the Teacher's Role in Classroom Discussion.

• What methods of teaching did you experience out in the field that related to the way that the teacher would participate in discussion in the mathematics classroom?

• How did these methods differ from the picture of how you perceived classroom discussion when you first entered the program?

• How has participating in the field experiences changed the way you believe you will be teaching when you get into your own classroom?

• What experiences contributed the most to that change, if perceived? The least?
• What ideas in the field experience with respect to the teacher's role in discussion in the mathematics classroom that you were not able to buy into? Give examples of when this occurred. Did you discuss these incidences with your cooperating teacher?

• How often did you or your cooperating teacher have the students work in small groups?
  - Describe the nature of the verbal interactions that took place during this time. Find out who was talking, about what, towards what goal.

• When you were teaching, how much explaining did you do?
  - How much time was spent questioning the students?
  - How much time did the students have to explore on their own and interact with one another?
  - How much time did the entire class participate in discussion?

• Of the three types of interactions mentioned above, which one to you think the students learn the most mathematics from?
  - Which one do they like the most?
  - How much time percentage-wise of each did you find yourself doing when you had a chance to teach the class?
  - What division of percentages would constitute your ideal allotment of time for each of these?

• Describe any ah-hah experiences you had while you were teaching? Explore any ramifications these experiences might have with respect to discussion.

IV. Model Teaching Experience.
• Imagine that you were responsible to teach a unit on fractions.

• If I were in your classroom while you were teaching that unit, describe what would I see during any discussion that would take place with the entire class. Ask about:
  - Who is talking?
  - Why they are talking?
  - How much they are talking?
  - What objectives do you have for the discussion?
• If I were in your classroom while you were teaching that unit, describe what I would see during any discussion that would take place with small groups. Ask about:
  - Who is talking?
  - Why they are talking?
  - How much they are talking?
  - What objectives do you have for the discussion?
Protocol: Third Student Interview

I hope that you have enjoyed your experiences during this past quarter in the mathematics education program. I would like to talk about some of those experiences with you, and the impact that they had on your ideas about your role in discussion while teaching mathematics. The word discussion as used here indicates the thoughtful and organized conversations that take place in the classroom while students form ideas about mathematical concepts. We'll use the same format as in the first interview. Okay? Let's begin.

I. Member check on prior experiences and beliefs.
Here is a picture of how I perceived your experience in the mathematics methods course and elementary school field experiences, and the ideas with respect to the teacher's role in discussion in the mathematics classroom that you formulated based on your responses to the second interview and comments that you made in your journal.

- Is that picture an accurate account of the way you perceived your role in discussion when I interviewed you at the end of the first quarter?

- If not, What aspects of that picture should be changed to better reflect your experiences?

My goal in this interview is to assess how these ideas have continued to develop during this past quarter, and what factors had the most influence on that development.

II. Student Knowledge Regarding Discussion Formats.

- Talk about your goals and intents for discussion segments of your classes.

- How do the different goals affect the format you use in discussion? How do different formats affect the nature of the discussions conducted?
• Which of these goals and corresponding formats do you consider the most effective?

III. Questions About the Ed. T&P 450 Course and Its Impact on the Student's Beliefs and Perceptions About the Teacher's Role in Classroom Discussion.

The 450 Course was the second education course in your teacher education program.
• What was the main focus of the Ed. T&P 450 course?

• How has participating in this course changed the way you believe you will be teaching when you get into your own classroom?

*If the student doesn't mention it, ask about their personality type as determined on the Myers-Briggs scale.*

• How would this impact on how you conduct discussion in your classroom?

• What methods of conducting discussion were modeled by the instructor?

• What aspects of the field experiences changed the way you believe you will be teaching when you get into your own classroom?

• We are talking about how the 450 class portrayed the teacher's role in discussion in the mathematics classroom. What were you not able to buy into? Why?
IV. Questions About the Mathematics Education Field Experience and Its Impact on the Student's Beliefs and Perceptions About the Teacher's Role in Classroom Discussion.

• You observed your cooperating teacher teach mathematics lessons in the middle school. How did he/she participate in the discussions?

• How did these methods differ from the picture of how you perceived classroom discussion as you have progressed through the program?

• Were there methods that he/she used that you were not able to buy into? Did you discuss these ideas with your cooperating teacher? If yes, did those discussions resolve the conflict?

• How often did you or your cooperating teacher have the students work in small groups?
  - Describe the nature of the verbal interactions that took place during this time. Find out who was talking, about what, towards what goal.

• The use of manipulatives was stressed in mathematics instruction during the last quarter. How often did you or the cooperating teacher utilize manipulatives while teaching? How did their use effect the discussions that took place when they were used?

• Calculators were also stressed in mathematics instruction during the last quarter. How often did you or the cooperating teacher utilize calculators while teaching? How did their use effect the discussions that took place when they were used?
• Problem solving was also stressed in mathematics instruction during the last quarter. How often did you or the cooperating teacher make problem solving part of instruction? How did using problem solving effect the discussions that took place when used?

• How did these experiences change the way you believe you will be teaching when you get into your own classroom?

• What experiences contributed the most to that change, if perceived? The least?

• Describe a typical lesson in your class. Estimate:
  - How much time was spent questioning the students?
  - How much time did the students have to explore on their own or with another student?
  - How much time did the entire class participate in discussion?
  - What division of percentages would constitute your ideal allotment of time for each of these?

• Of the three types of interactions (Explaining, questioning, exploring), which one do you think the students learn the most mathematics from?
  - Which one do you think the students learn the most mathematics from?
  - Which one do they like the most?

• How often did you get to discuss your lessons with the cooperating teacher? What was discussed? What effect did this have on your teaching?
V. Student's Self Assessment of Teaching.
I would like to have you hear two 5 minute excerpts of your own teaching to see if they are representative of how you typically taught. *I will play two excerpts that come from the audiotape recordings of the students' lessons, one that represents what I felt was a typical example of the students' teaching, and another that differs in behavior. After describing the scene for the student, the following questions will be asked.*

- What aspects of this excerpt typical of the way that you conducted your classes? atypical?

- What strengths do you feel you exhibited in this excerpt? weaknesses?

- What would you have done differently if you had the chance to do it over again? Why?

- I have observed you talk about (here insert a specific event that the student has alluded to on several occasions). Describe that experience and how it has affected your teaching.

VI. Participation in the class seminar.
This quarter you met with Dr. Suydam and your colleagues to discuss readings from the NCTM *Professional Standards for Teaching Mathematics.*

- What impact, if any, did this experience have on the way you think about teaching?What readings discussions contributed the most?

- Three of the Standards involve discourse. In what ways did this provide new insights into the way discussion is conducted in the mathematics classroom?
• What parts of the these Standards do you buy into? do not buy into? Why?

• How do your present practice reflect the methods supported by the Standards?

VII. The Impact of the University Supervisor.
• On how many occasions were you observed by your supervisor?

• What type of feedback did you receive from the university supervisor?

• In what other ways did you interact with the university supervisor?

• What impact did these interactions have on the way that you presently think about teaching?

VIII. Contact with Classmates.
You have been with your classmates for two quarters now. You probably have occasions to discuss what you've been learning.
• How much time did you spend in this type of informal discussion?

• What was usually the main focus of these discussion?

• What influence does this have on your teaching?
IX. Model Teaching Experience.
In the last interview, I asked how you would teach a unit on fractions. During this last quarter, you've taught the concept of fractions to students or have utilized fractions in parts of other lessons. Imagine that you were again responsible to teach a unit on fractions.

- Describe how the lesson to teach the concept of equivalent fractions would be taught.

- If I were in your classroom while you were teaching that lesson, describe what would I see during any discussion that would take place with the entire class. Ask about:
  - Who is talking?
  - Why they are talking?
  - How much they are talking?
  - What objectives do you have for the discussion?

- If I were in your classroom while you were teaching that unit, describe what I would see during any discussion that would take place with small groups. Ask about:
  - Who is talking?
  - Why they are talking?
  - How much they are talking?
  - What objectives do you have for the discussion?

X. Students Evaluation of the Program.
- I'm sure you had some expectations coming into the mathematics education program. What aspects of those expectations were or were not met?

- What would help you develop the skills that you need to become an effective teacher in conducting discussion?
• Describe your image of how you would conduct discussion in the mathematics class when you first came into the program and compare it to how you perceive how you would now conduct discussions.

• What might prevent you from practicing that image as you now perceive it in the classroom?
Thank you for being willing to participate in this study to examine the effects of methods courses in the teacher education program and related field experiences on the beliefs of the preservice teachers about their role in classroom discussion. The following questions will allow me to determine the nature of the course in which the students will participate.

(The following questions or issues constitute an interview guide that are to be explored during the course of the interview. No particular order need be followed, as long as all the questions are addressed.)

I. Mathematics Learning and Teaching Presented to the Students During the Course.
   • What theories of learning will be presented to the students during this methods course?
   • What theories of learning mathematics will be presented to the students during this methods course?
   • What methods of teaching mathematics linked to these theories will be presented to the students during this methods course?
   • What methods of conducting mathematics classroom discussion will be taught to the students during this methods course?
   • What affect will the recommended reform as envisioned by the NCTM's Curriculum and Evaluation Standards for School Mathematics and the Professional Standards for Teaching Mathematics have on the material covered in this course?

II. Course Objectives.
   • What specific objectives have been determined for the students with respect to their role in discussion in the mathematics classroom?

III. Attainment of Course Objectives.
   • Describe the methods you plan to utilize in order to attain your objectives.
• How will the teaching methods being taught in this methods course be practiced?

• How will the teaching methods being taught in this methods course be modeled by the instructor?

• How will the course objectives be linked to the field experiences?

IV. Student Assessment of Attainment of Objectives.

• How will students be assessed on their knowledge of their understanding of their role in mathematics classroom discussion?

• How will students be assessed about their beliefs about their role in mathematics classroom discussion?
Protocol: Mathematics Methods Instructor Second Interview

Thank you for having participated in this study to examine the effects of the methods courses in the teacher education program and related field experiences to the beliefs of the preservice teachers about their role in classroom discussion. By discussion we are referring to the thoughtful and organized conversations that take place in the classroom while students form ideas about mathematical concepts. The following questions will allow me to determine the results of the students having participated in the course.

(The following questions or issues constitute an interview guide that are to be explored during the course of the interview. No particular order need be followed, as long as all the questions are addressed.)

I. Mathematics Learning and Teaching Presented to the Students During the Course.
   • Were the theories and methods of teaching covered in the methods course as proposed in the first interview? If not, what were the obstacles encountered that inhibited them being taught?

II. Attainment of Course Objectives.
   • Were the course objectives as proposed in the first interview fully attained? If not, what were the obstacles encountered that inhibited them being attained?

   • How were the teaching methods being taught in this methods course practiced?

   • How were the teaching methods being taught in this methods course modeled by the instructor?

   • How were the course objectives linked to the field experiences?

IV. Student Assessment of Attainment of Objectives.
   • How were students assessed on their knowledge of their understanding of their role in mathematics classroom discussion?
• How were students assessed about their beliefs about their role in mathematics classroom discussion?

• Did students indicate that methods course participation led to a change in their perceptions or beliefs about their role in mathematics classroom discussion? If yes:
  
  • In what aspects of their role did the conflict arise?
  
  • What activities contributed most to that conflict?
  
  • How were students able to resolve that conflict?
Protocol: Cooperating Teacher Interview

As you know, (give the name of the student), participated in a study to examine students' incoming perceptions of the teacher's role in class discussion and to see how those perceptions evolved during their participation in their methods classes and their field experiences. This is now the second field experience that (student's name) has had, and I would like to continue to evaluate that evolution. Your responses during this interview will be completely confidential and will be used to evaluate the impact of the field experiences in any observed changes in the perceptions and beliefs of (Give the name of the student).

I. Teaching Behaviors of the Cooperating Teacher. First I would like to see what teaching methods were observed by (student's name).

- How often did (Give the name of the student) observe groups used in instruction in your classroom?
  - What strategies would (student's name) have seen you employing during this type of instruction?

- How often did (Give the name of the student) see the class involved in full-group discussion.
  - What strategies would (student's name) have seen you employing during this type of instruction?

- If a student was working individually on a mathematics problem in class and got stuck, what would you do in response to the student's inability to proceed?
• Sometimes students come up with their own ideas about mathematical concepts. For instance, a student might add 2/3 and 1/2 to get 3/5, explaining that you add the numerators and add the denominators when adding fractions. What would you do in response to students' ideas like these?

• Teachers take many roles while discussing mathematical concepts with students. How often did (Give the name of the student) see you doing the following:
  - Demonstrating a skill to the whole class.
  - Moderating interstudent discussions.
  - Posing questions that ask students to hypothesize or generalize.
  - Posing questions to to elicit or challenge student thinking.
  - Wait for students to respond and accepting responses when given.
  - Explaining concepts to the students as a group.
  - Listening to students work cooperatively on problems that you have assigned.
  - Monitoring students as they work individually on their assignments at their desks.
Name any other teacher behaviors involving discussions that are not listed here.

II. Questions About the Student's Experiences.

• How often did (Student's name) teach the entire class last quarter?

• When (give the name of the student) taught a lesson, how often did he/she exhibit:
  - Demonstrating a skill to the whole class.
  - Moderating interstudent discussions.
- Posing questions that ask students to hypothesize or generalize.
- Posing questions to elicit or challenge student thinking.
- Wait for students to respond and accepting responses when given.
- Explaining concepts to the students as a group.
- Listening to students work cooperatively on problems that you have assigned.
- Monitoring students as they work individually on their assignments at their desks.

• What other types of experiences did (Student's Name) have in your class during the last quarter?

III. Questions About Change in the Student's Beliefs and Perceptions About the Teacher's Role in Classroom Discussion.

• How often did you discuss teaching with (Student's Name) during the quarter? What did the discussion usually focus on?

• When discussing either your teaching or the student's teaching after a class, did you focus on any of the following aspects of their role as the teacher in classroom discussion listed above?

• Through your contacts with (give the name of the student), what changes that took place with respect to his/her beliefs and perceptions about the teacher's role in classroom discussion were you able to observe?
  - If yes, what seemed to contribute most to those changes?
IV. Demographic Questions.

• How long have you been teaching?

• Have you had students for field experience before?

• Are you a member of the NCTM?

• What interactions have you had with the university supervisor during this past quarter?
Protocol: General Methods Instructor Interview

Thank you for being willing to participate in this study. The object of this study is the development of students' beliefs about their role in mathematics classroom discussion. Since you were in contact with the student during this past period of development, your interactions with the student are important.

The objective of the course was to increase preservice teacher's awareness and understanding of school-aged learning development and its relation to individual diversity and teacher effectiveness. We will look at the course's impact on the way students perceive their role in conducting discussions in the mathematics classes. By discussion we are referring to the thoughtful and organized conversations that take place in the classroom while students form ideas about mathematical concepts.

I. Impact of the Course Content.

• From your observations of and contacts with (student's name), how did the following topics covered in the course affect his/her perception of the teacher's role in discussion.

  - student development
  - learning theories
  - learning styles
  - motivation

• Describe the impact other topics not mentioned above had on the student's perception of the teacher's role in class discussion.

II. Teaching Experiences.

The students participated in several types of teaching experiences: reflective teaching, simulations, and field experiences.
• Describe what impact these experiences had on (student's name) perception of the teacher's role in discussion.

III. Modeling of Conducting by the Professor.

The student's also observed you as you conducted discussions in the classroom.

• Describe the different formats that were used while conducting discussions in the course.

• Describe the different roles that you took while conducting discussions in class.

• How much opportunity did you have to discuss personally these aspects of teaching with (student's name).

Can you add any of your own perceptions with respect to how this course might have influenced (student's name) perception of his/her role in conducting discussion?
Protocol: University Supervisor Interview

Thank you for being willing to participate in this study. The object of this study is the development of students' beliefs about their role in mathematics classroom discussion. By discussion we are referring to the thoughtful and organized conversations that take place in the classroom while students form ideas about mathematical concepts. Since you were in contact with the student during this period of development, your interactions with the student are important.

I. Contact Hours.
   • How often did you observe the students during their field experiences?

   • Describe (student's name) basic approach to his/her role in the discussions conducted in the classroom.

   • What other different roles in discussion did you see (student's name) take during your observations?

   • What contact did you have with the students to discuss classes that you have mutually observed or observations you've made of the students teaching?
     - During those contacts, what aspects of their role during discussion did you talk about?

     - What expectations did you have for the students in how (student's name) conducted discussion?

     - How well did (student's name) realize those expectations?
• In reading the students journals, what experiences did (student's name) write about that might have shaped the students views on how discussion is conducted in the classroom?

• What changes occurred in (student's name) way of conducting discussions during the last quarter?
  - What influences had the most impact on those changes?

• What aspects of the methods course or field experiences was (student's name) unable to buy into during the course of the quarter?

• If (student's name) were to teach a unit on fractions, what different approaches would you be likely to observe in the lessons that made up the unit?

II. Function as Liaison.
• What efforts did you make to tie the methods class instruction together with the field experiences?
• In your contacts with the cooperating teacher, what aspects of (student's name) development as a teacher with respect to the teacher's role in discussion did you discuss?

• What methods of teaching did the cooperating teacher model for the student with respect to the role of the teacher in discussion?

• What aspects teacher talk did you identify that (student's name) will have to work on?