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In their own voice: a study of preservice early childhood and elementary teachers reconstructing their beliefs about teaching and learning mathematics.

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IN THEIR OWN VOICE: A STUDY OF PRESERVICE EARLY CHILDHOOD AND ELEMENTARY TEACHERS RECONSTRUCTING THEIR BELIEFS ABOUT TEACHING AND LEARNING MATHEMATICS

A Dissertation Presented

by

BARBARA D. HENRIQUES

Submitted to the Graduate School of the University of Massachusetts Amherst in partial fulfillment of the requirements for the degree of

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School of Education
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DEDICATION

This dissertation is dedicated to a very special person in my life. A person who has consistently inspired me through her acts of generosity and love and by her abiding faith. The world would be a far, far better place if more of us could spend time with you. We have shared you as freely as we could because we know you have been a treasure too valuable to hold onto too tightly.

Mom, this is for you, for all your love and the spirit of life you have shared.
I would like to thank the following individuals for their support and encouragement of my work: the Chair of my dissertation committee, Dr. Howard A. Peelle; additional members of the committee; Dr. R. Mason Bunker, Dr. Jon L. Sicks, and Dr. Portia C. Elliott; the members of the faculty I have worked with at the School of Education; my colleagues who continue to support one another in our learning; and the preservice teachers who agreed to participate in this study and allowed me to hear their voices so clearly.

I'd also like to acknowledge the tremendous assistance provided by the support staff of the School of Education. Your insights and encouragement have been most appreciated.

I would also like to acknowledge my family and friends who have endured, in spite of the stresses and the hardships, to consistently support and encouragement along this journey. You share in my accomplishment and will always be a vivid part of my memory of this experience.

Finally, a special note of appreciation to my friend, Joan, who insisted I could do this and supported me through to the finish. My thanks to you and your family for your generous support.
ABSTRACT

IN THEIR OWN VOICE: A STUDY OF PRESERVICE EARLY CHILDHOOD AND ELEMENTARY TEACHERS RECONSTRUCTING THEIR BELIEFS ABOUT TEACHING AND LEARNING MATHEMATICS

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This study focused on preservice teachers at early childhood and elementary levels to identify prior beliefs they bring to their mathematics methods classes, how these beliefs affect their understandings about mathematics teaching and learning, and how these beliefs are reconstructed while engaged in a constructivist designed mathematics methods course.

Data collected included in-depth student journal entries, personal histories of preservice teachers' prior mathematics experiences, and small group interviews. An interpretive analysis of the data identified emergent themes related to preservice teachers' beliefs about themselves as learners and teachers of mathematics and how these beliefs were reconstructed during the course.

Five major themes were identified: preservice teachers prior beliefs and experiences; increased understandings about themselves as learners of mathematics; new learning about mathematical pedagogy; new or different
ways of learning mathematics; and anger about their previous mathematics experiences.
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CHAPTER I

INTRODUCTION TO THE STUDY

Statement of the Problem

Educators and researchers in the fields of mathematics education and learning theory have advocated major reform in mathematics teaching and learning consistent with current needs within our society and reflective of advances in our understandings of learning theory. While major efforts have been made to address the roles of teachers, they have been focused primarily on in-service teacher education and have addressed preservice teacher education minimally. Preservice teachers need to experience content and pedagogy in ways that challenge their prior beliefs about mathematics and about themselves as teachers and learners of mathematics if they are to become agents of effective and dynamic change in mathematics education reform efforts.

The education of teachers is a complex undertaking that generally involves a series of preservice, in-service and staff development experiences. These experiences augment the individual experiences teachers gain through years of classroom teaching. The education of teaching professionals is a process that continues throughout a teacher's career. This study focuses on the initial stage of this process, preservice education. It is limited to the preservice education of early childhood and elementary teachers, specifically in the area of mathematics.

Our nation has been engaged in major reform efforts in mathematics education since the 1980's. These reform efforts have focused on changes in curriculum and instruction, teacher education, and assessment and evaluation procedures. While some of these efforts have focused on the preservice level,
the vast majority have centered on teacher education at the in-service level. Grouws and Schultz (1996) identify the need for additional research in teacher education based on two current conditions. One of these is that while the major expansion of mathematics education research over the last twenty years continues, it has yet to focus significantly on teacher education. Secondly, the reform efforts that are underway in mathematics report continued deficiencies in student learning in mathematics, and thus far have not had a major impact on teacher education programs.

**Motivation for the Study**

In my experience as a teacher educator, working with elementary classroom teachers over the past twenty-five years, I have become aware that many teachers have concerns related to the teaching of mathematics. In discussions with teachers, they have indicated that they do not feel comfortable teaching mathematics. Their knowledge of mathematics is primarily a procedural one rather than a conceptual one. They tend to view mathematics as a set of rules, formulas, and routines. The vast majority of these teachers do not view mathematics as a dynamic subject imbedded in our society and culture. Alan J. Bishop in the preface to his book, *Mathematical Enculturation*, states:

> Mathematics is in the unenviable position of being simultaneously one of the most popular school subjects for today’s children to study and one of the least understood. Its reputation is awe-inspiring. Everybody knows how important it is and everybody knows that they have to study it. But few people are comfortable with it; so much so that it is socially quite acceptable in many countries to confess ignorance about it, to brag about one’s incompetence at doing it, and even to claim that one is mathophobic (p. xi)!

In my experience working with teachers, many of them speak openly of their uncertainties as to what they should be doing in teaching mathematics. Many
adhere to a traditional textbook approach to teaching mathematics and limit hands-on investigations to other curriculum areas. This concerns me. If students are to experience mathematics in a meaningful way, they need to see how mathematics is involved in the real world. They need to experience mathematics in the real world of problem solving. If teachers do not experience mathematics as a dynamic subject, how can their students experience and understand mathematics as a dynamic, engaging subject? How can their students develop "mathematical power?" These questions continue to concern this researcher both in her role as a teacher educator and as an individual who believes that mathematics is a powerful cultural tool.

Major programs, supported by public and private funds, have been developed to engage teachers in rethinking their beliefs and understandings about mathematics teaching and learning. These programs have focused predominantly at the in-service level. While these programs must continue, it is imperative that concurrent efforts be directed to the education of preservice student teachers in mathematics. Efforts designed to address the needs of preservice teachers must include consideration of the beliefs preservice elementary teachers bring with them to their teacher education experiences (Mathematics Education Development Center, 1990; Melnick, 1992). The literature points out that generally preservice teachers, especially at the early childhood and elementary levels, enter these programs with a limited view of what mathematics teaching entails (Ball, 1990; Feiman-Nemser, 1987; Lampert, 1988; Wheeler, 1983; Wilcox, 1991. The assumptions preservice teachers hold about mathematics and mathematics teaching have primarily been formed based on their experiences as precollege students. Richardson (1996), Ball (1990), and Lampert (1988) state that prospective teachers are not "prepared to teach mathematics for understanding nor to teach mathematics in
a way that differs from the traditional pedagogy of telling and drilling
algorithms into students" (p. 10). This view conflicts with established learning
teachers. Wilcox, Schram, Lappan, theory on the nature and construction of knowledge. Wilcox, Schram, Lappan,
and Lanier (1992) state:

Preservice teachers bring with them pedagogical and epistemological orientations that conceive teaching and learning as matters of technical competence. They expect their professional studies to provide the techniques to make them efficient and effective teachers. If teacher educators are to cause prospective teachers to rethink these beliefs, we must create situations where these beliefs are faced and reconsidered (p. 2).

There is a continued need to engage prospective teachers in rethinking their beliefs about mathematics and in increasing their awareness of the implications these beliefs have on their understandings of mathematics content and pedagogy.

Purpose and Significance

The purpose of this study is to examine how preservice teachers engage in reconstructing their beliefs about mathematics learning and teaching. The study addresses the prior experiences preservice teachers bring to their mathematics methods classes and how these experiences affect their beliefs about themselves as learners and teachers of mathematics. Kennedy (1991) states:

We need to define teacher learning as both a function of the teacher-learner and of the learning experience itself. We must design research that examines both what teachers bring with them to new experiences--what they already know, believe, or value--and the experiences themselves--the features that are likely to promote learning the new ideas or practices offered to them (p. 2).

The mathematics methods course which participants in the study have been enrolled in is designed to foster active engagement of learners in the process
of reconstructing their beliefs about mathematics and about themselves as learners and teachers of mathematics. The course is designed to promote constructivist teaching/learning practices.

The significance of this study is that it addresses preservice teachers' prior experiences and the effect these prior experiences have on their beliefs about themselves as learners and teachers of mathematics. The study addresses the effects of these experiences in a mathematics methods class designed to promote constructivist teaching practices. Engagement in this class experience is designed to build a more collaborative definition of teacher/learner. This collaborative definition acknowledges the previous experiences and beliefs preservice teachers bring to their education. Building upon the work of Ball (1990), Eisenhart, et. al. (1993), Schram, et. al (1988), and Wilcox, et. al. (1992) this study engaged learners in practices which encouraged the challenging of previously held beliefs and, at the same time, enhanced the development of pedagogical practice to more appropriately meet the needs of future learners. Ultimately, it is expected that this practice will stimulate preservice teachers to question and implement pedagogical practices which will be useful in their future classrooms.

This study focuses on the mathematics education of early childhood and elementary preservice teachers. It has been found that the vast majority of preservice teachers hold beliefs which include:

- mathematics consists of a fixed set of procedures,
- mathematics is viewed as a static body of knowledge rather than as a dynamic subject, and
- mathematics is not embedded in our culture (Ball, 1993; Bishop, 1991; Melnick, 1992).
These beliefs are well documented in the mathematics reform literature. (See Chapter II.) These beliefs assume increased significance when we recognize the importance of such beliefs in that they may dramatically impact what occurs within the mathematics curriculum. These beliefs have the potential to significantly impact on the dispositions teachers and students bring into the mathematics classroom. These beliefs may also affect a student's inclination to study mathematics and may even affect the student's level of engagement with the subject.

**Research Questions**

In an effort to clearly identify and address this problem, I developed a set of research questions which have guided this study. These questions have evolved as my understanding of the problem and it's significance have gained greater concern from teacher educators working with preservice students.

- What prior experiences about mathematics and about mathematics learning and teaching do preservice teachers bring to their mathematics methods class?

- How do these prior experiences affect preservice teachers' beliefs about themselves as mathematically thinking individuals and about themselves as learners and teachers of mathematics?

- How are these beliefs reconstructed during their involvement in a mathematics methods class designed to promote mathematics learning as a constructivist activity?
What factors do preservice student teachers identify that contribute to the reconstruction of their beliefs about themselves as learners and teachers of mathematics?

These questions focus on preservice teachers' beliefs about mathematics, about mathematics learning and teaching and about themselves as doers of mathematics. They also address how these beliefs may be reconstructed through involvement in a mathematics methods class designed to promote rethinking of their previously held beliefs about mathematics, mathematics learning and teaching.

Materials generated throughout the preservice course such as initial questionnaires, journal entries, small group interviews and final questionnaires will be utilized to voice preservice teacher beliefs, and based on these findings themes which emerge from the data will be identified.

Limitations

The findings that result from this study may prove valuable for mathematics teacher educators in their work with preservice teachers. However, there are factors which may also limit generalization of the findings to the broader educational community. These include the following:

1. The setting of this study, while not unique, differs from many preservice programs in that:
   a. students are selected to participate in the teacher education programs based on an application process that includes the submission of a portfolio of their experiences, philosophy of education, and previous experiences working with young people. This is followed-up by an in-depth interview with members of the department;
b. the methods courses for students participating in this study share a common philosophy, which is grounded in a constructivist approach to learning; and

c. the participants are involved in educational programs that require concurrent field-based experiences while students are enrolled in pedagogical related coursework.

2. This study focuses on preservice teachers for one semester while enrolled in a mathematics methods class. It does not follow participants through their full-time student teaching experience or into their classrooms as they begin their teaching careers.

While these factors may limit generalization to the broader educational community, I believe the findings generated from this study will have a positive, significant affect on mathematics teacher educators as they strive to meet the challenge of teaching preservice students in courses that share "epistemological harmony" (Underhill, 1994) with the pedagogical methods preservice teachers are to use in their future classrooms.
CHAPTER II

REVIEW OF THE LITERATURE

The literature reviewed in this section is meant to be representative of the major issues associated with the proposed study. This study focuses on preservice teachers engaged in a mathematics methods course designed along constructivist teaching practices. The first section of the literature review centers on literature related to the four major components which have guided the development of the course and learner interactions in the course. The four components addressed in this section are: constructivism, beliefs, change, and community. A second section of the literature review addresses reform efforts in mathematics education and programs which support teachers engaged in reform efforts.

Theoretical Perspective

In the first section I begin with an overview of constructivist learning theory. Constructivism provides the philosophical underpinnings of this investigation. The focus of the review on constructivism points to the dynamic nature of constructivist learning theory.

This is followed by a review of related research on beliefs. Beliefs strongly influence students' perceptions of themselves as learners and have implications for future teaching practices. Engaging preservice teachers in constructivist learning situations enhances opportunities for changes in beliefs and ultimately in actions (Richardson, 1996).

Literature related to change is included in this section to inform an understanding of the process of change. In this section I examine literature specifically related to the multi-dimensionality of the change process.
The final component of this section focuses on literature related to creating learning communities in the mathematics classroom. Learning communities are marked by components that engage learners in active involvement in the dynamics of the classroom. Learners in these classrooms assume greater personal responsibility for their learning and the actions which result from that learning.

**Constructivism**

The philosophical underpinnings of this investigation are grounded in the theory of constructivism. Constructivism is a theory of intellectual development which argues that learners must actively engage in the construction of their ideas, understandings and concepts about the world. Constructivist theory believes that learning occurs as the learner acts on his/her environment. Building on the work of Piaget (1963a), constructivists have transformed the way we think about intellectual development and our understandings of how children view the world (Confrey, 1994b; Nicolopoulou, 1993). These insights have shaped much of the current reform movement in mathematics (California State Department of Education, 1987; National Council of Teachers of Mathematics, 1989; National Research Council, 1990; Schifter, 1993).

The ongoing development of constructivist theory has followed a systematic progression toward ever-increasing understandings about the construction of knowledge. Beginning with the work of Piaget (1963b), constructivist theory has evolved to include contributions from the work of Vygotsky (1978), Papert (Harel, 1991), von Glasersfeld (1994) and Confrey (1994a). These contributions have furthered our understandings of the nature and process of constructivist learning.
Piaget proposed a developmental framework which focused on the learner constructing knowledge internally. Using this model, knowledge was viewed as being constructed within the learner as he/she engaged in situations that generated a questioning of previous learning. This state, referred to as a "state of disequilibrium," engages learners in the construction of new learning as they encounter learning that conflicts with previously constructed knowledge.

Vygotsky expanded our understanding of the construction of knowledge to include a socio-cultural dimension. A major component of constructivism from Vygotsky's perspective depends upon the interpersonal engagement of the learner with other learners (Van Der Veer, 1993). Vygotsky argues that knowledge is constructed as the learner engages in learning opportunities that involve the learner at an appropriate level of conflict. The construction of new learning occurs most effectively when the learner engages in tasks which are within the learner's "zone of proximal development" (Tudge, 1993). Vygotsky defined this as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (1978, p. 86). Vygotsky's work promotes the design of educational contexts for learning that promote interaction between learners.

Vygotsky's model of the social construction of knowledge has led Papert to the development of the theory of "constructionism." Constructionism is an extension of constructivism where the learner engages in visible construction of models of their understandings by creating constructions of real world models (Harel, 1991). Constructionism has been utilized most successfully in the understanding of student learning through the writing of computer
programs to model student thinking. While this investigation will not focus on constructionism, it is important to our understanding of the continued development of theories of constructivism.

Finally, the most recent development in constructivist literature focuses on the work of von Glasersfeld (1990) and Confrey (1994) and is termed "radical constructivism." Confrey states that political and social factors have created a need to revise the theories of constructivism put forth by Piaget and Vygotsky. These factors include: "changing demographics, a reform climate in education, the creation of new technologies, the press of environmental concerns, and issues of power and oppression" (p. 2). Confrey supports the theory of radical constructivism as a means to challenging the traditional evaluative climate of the mathematics classroom (p. 5). Von Glasersfeld states:

radical constructivism does not suggest that we can construct anything we like, but it does claim that within the constraints that limit our construction there is room for an infinity of alternatives. It, therefore does not seem untimely to suggest a theory of knowing that draws attention to the knower's responsibility for what the knower constructs (p.28).

Radical constructivism has powerful implications for teaching and learning in the classroom. These implications include greater responsibilities for the teacher in providing constructivist teaching opportunities that are consistent with students levels specifically in regard to authentic assessment of learner understandings and appropriate intervention based on these understandings. Confrey (1990) tells us,

When one applies constructivism to the issue of teaching, one must reject the assumption that one can simply pass on information to a set of learners and expect that understanding will result. Communication is a far more complex process that this. When teaching concepts as a form of communication, the teacher must form an
adequate model of the students' ways of viewing an idea and s/he then must assist the student in restructuring those views to be more adequate from the students' and from the teacher's perspective (p.109).

Other research studies in mathematics education have been grounded in theories of constructivism that focus chiefly on the work of Piaget and Vygotsky (Betke, 1993; Confrey, 1990; Davis, 1990b; Goldin, 1990; Melnick, 1992; Noddings, 1990). Bussis, Chittenden, and Amarel (1976) have found that significant change occurs when learners engage in "personal exploration, experimentation, and reflection" (p.17). This level of engagement is consistent with constructivist learning theory and the approach is replicated in studies of teacher change, as well as, preservice teacher change (Fosnot, 1989; Schifter, 1993; Underhill, 1994).

Beliefs

This investigation will focus on preservice teachers' beliefs about teaching and learning mathematics. While many educators argue that their actions in the classroom are the direct result of knowledge, Feiman-Nemser and Floden (1986) point out that this may not necessarily be the case. Many of the actions that occur in the classroom may be determined by beliefs, not knowledge. Much of the educational literature finds the terms beliefs and knowledge used interchangeably. Alexander, Schallert, and Hare (1991) equate beliefs and knowledge as follows: "knowledge encompasses all that a person knows or believes to be true, whether or not it is verified as true in some sort of objective or external way" (p. 317). A review of the literature on beliefs indicates that researchers use a variety of terms to address the concept. These terms include: attitudes, beliefs, conceptions, theories, understandings, practical knowledge, and values (Richardson, 1996).
Preservice teachers, especially those at the early childhood and elementary levels, enter teacher education programs with beliefs that have been acquired throughout their earlier educational experience. These beliefs generally include: viewing mathematics as a fixed body of knowledge, a content issue; viewing the teacher as carrying out goals determined by texts, a pedagogical issue; and viewing teacher education programs as the means to techniques to make teaching mathematics efficient and effective. Prior held beliefs develop over time and if they are to change, these beliefs must be challenged over time. Ball (1990), Eisenhart, et. al. (1993), Schram, et. al. (1988), and Wilcox, Lanier, Schram, and Lappan (1992) have researched the prior beliefs of preservice teachers. These studies have focused on preservice teachers' beliefs, concepts and understandings about mathematics. Ball (1990) concludes from her study of preservice elementary and secondary teachers that it is imperative that teacher education programs address the subject matter preparation of teachers. She states:

Attending seriously to the subject matter preparation of elementary and secondary math teachers implies the need to know much more than we currently do about how teachers can be helped to transform and increase their understanding of mathematics, working with what they bring and helping them move toward the kinds of mathematical understanding needed in order to teach mathematics well" (p. 465).

Additional research that focuses on specific mathematical concepts supports these findings (Cooney, 1993; Simon, 1993; Simon & Blume, 1994; Wilcox, 1991).

Melnick's (1992) research focuses on preservice teachers as learners of mathematics. His work has focused on preservice teachers' previous experiences as learners of mathematics and the use of constructivist teaching practices to effect change. The study, though limited to five students,
employed a longitudinal dimension and focused directly on the previously held beliefs preservice teachers bring to a mathematics methods class and how those beliefs affected a change in beliefs.

Studies which have examined the beliefs of preservice teachers indicate that constructivist teaching and learning practices promote opportunities for beliefs to surface and be acknowledged (Cobb, 1990; Feiman-Nemser, 1987; Hollingsworth, 1989; Lampert, 1988; Melnick, 1992; Underhill, 1994). Teacher education programs must provide opportunities for preservice teachers to challenge their conceptions regarding the teaching and learning of mathematics if these programs are to "make a difference in the deep structure of knowledge and beliefs held by the students" (Richardson, 1996, p. 106).

The Process of Change

This section will provide an analysis of some of the current research on how change occurs. I will focus on the process of change and the various stages of the change process.

Teacher education programs designed along constructivist teaching practices encourage preservice teachers to engage in questioning previously held beliefs and the implications of those beliefs on actions within the classroom. This is a complex process and one that has been the subject of numerous studies. Fullan (1992) suggests a theory of educational change that identifies three distinct levels of change. He points out that the multi-dimensionality of the change process must be recognized if change is to have a significant impact on future practice.

The three stages Fullan describes are marked by increasing levels of personal ownership of the change process. The first stage in the change process involves change at a superficial level. At this level, it looks like
change has been implemented because materials advocated to promote the change are being used. This level of change may not create any meaningful change in the lives of students in the classroom and may not affect teacher practice within the classroom. Change must move to the next level to have meaning that impacts classroom practice and personal ownership. At this second stage teachers begin to use their understandings of the change to alter classroom practice. The change has an increased effect on the learning that occurs in the classroom and the level of involvement on the part of students. Fullan argues that for meaningful change to occur it must proceed to a third stage that involves a rethinking of beliefs. Teachers engaged at this level of the process of change become engaged in rethinking their beliefs about the proposed change. This involves thinking about how they teach and why they teach. It also involves a rethinking of their role as a teacher and of the students' role as a learner. Schifter and Fosnot discuss this change process as "the difference between implementing specific teaching strategies and operating out of a particular structure of beliefs about learning and knowing—an epistemological perspective" (1993, p. 186). The SummerMath for Teachers Program (1986) has developed a tool for assessing instruction based on a constructivist epistemology referred to as the Assessment of Constructivism in Mathematics Instrument (ACMI). The ACMI correlates to increasing levels of complexity in the development of constructivist teaching practices.

Wilcox, Schram, Lappan, and Lanier (1991) have found that efforts to engage preservice teachers in changing their thinking about mathematics do not extend to include changes in their beliefs about mathematics teaching in the classroom. This is in part due to the lack of practical knowledge preservice teachers bring to their mathematics courses. Referring to the levels
of change described by Fullan (1992) and Schifter and Fosnot (1993), we see that this lack of practical knowledge has direct implications for the level of meaningful change preservice teachers can achieve. The ACMI instrument identifies Level III as having "a rudimentary understanding of constructivism, but difficulty basing instruction on this understanding" (Schifter, 1993, p. 188). Levels IVA and IVB of this instrument require being able to utilize a constructivist epistemology in both their instructional practice and in their understandings of student learning. These levels of change are accessible to individuals who have operated from a constructivist philosophy and can access that constructivist orientation in designing, implementing, and understanding learning within the classroom. Many studies which address change in preservice teacher beliefs point to the continued need for programs that focus on components that engage preservice teachers in acquiring practical knowledge regarding the implementation of constructivist teaching and learning practices (Hollingsworth, 1989; Melnick, 1992; Wilson, 1991).

The literature which addresses meaningful educational change, and the process involved with such change, has implications that will enhance the success of teacher education programs in developing educational practices which support learners engaged in the process of rethinking their actions in the classroom.

Creating a Learning Community in Mathematics

Numerous interventions grounded in constructivism have been developed to create change in the preservice education of teachers of mathematics. The work of Wilcox, Schram, Lappan, and Lanier (1991) identify the creation of a learning community as a powerful influence in enhancing preservice teachers' self-confidence as mathematical problem solvers. Learning communities are important in creating places where students can
engage one another in generating shared knowledge and in establishing a culture for inquiry (Schoenfeld, 1989).

A learning community engages students in collaboration and shared responsibility for understanding. Betke (1993) identifies the role of question posing, by students, in the mathematics classroom as critical to building shared responsibility. Von Glasersfeld states that to "solve a problem intelligently, one must see it as one's own problem (von Glasersfeld, 1990, p.15). Schifter (1990) continues this idea in stating that the distance between the learner and the subject matter changes in these situations from one of distance to one of intimacy. In learning communities that minimize the distance between the learner and the subject, students engage in a higher level of mathematical discourse and questioning. In such communities students are encouraged to continue to think about problems and to reflect on what they have learned. Frequently, this is a new experience for students who have traditionally looked to the teacher as the ultimate authority in the classroom. In such communities the teacher no longer functions as the sole source of authority in the classroom. Researchers describe this as a shift in epistemological authority in the classroom (Betke, 1993; Confrey, 1994a; Fosnot, 1989; Goldin, 1990; Hollingsworth, 1989; Melnick, 1992; Schifter, 1990; von Glasersfeld, 1990).

The creation of learning communities in teacher education programs engages preservice teachers in a more powerful role in their own learning. A community engaged in mathematical discourse related to the teaching and learning of mathematics encourages the sharing of ideas and beliefs. It is through the process of confronting beliefs and reflecting on actions directed by those beliefs that change occurs. The National Council of Teachers of Mathematics (NCTM) Professional Standards state that preservice teachers
must experience good mathematics teaching, increase their knowledge of mathematics, understand children as learners of mathematics, and know mathematical pedagogy (1991, pp. 128-151). Preservice teachers who experience such practices in their teacher education programs are more likely to incorporate such practices in their classrooms (Hollingsworth, 1989).

Reform Efforts in Mathematics Education

This section provides a survey of the reform literature in mathematics education. It is designed to include a historical review of the background of reform efforts. Also included is a discussion of some of the major efforts designed to support teachers engaged in reforming mathematics education in their schools and classrooms.

Review of the Reform Movement

Educators and researchers in the fields of mathematics education and learning theory have advocated reform of mathematics teaching and learning consistent with current needs within our society and reflective of advances in our understandings of learning theory. The increased need for mathematics in today's society is necessitated by the increased role of science in our culture and rapid advances in the development of technology--especially the growth in the use and potential uses of computers in our daily lives.

The National Assessment of Educational Progress has continued to point out consistent weaknesses in the performance of American students in solving mathematics problems (Romberg, 1993). In addition, research in learning theory has identified the need for a more constructivist approach to the learning of mathematics. Building on the work of Dewey, Piaget, Vygotsky, and others, mathematics educators recognize that a curriculum that engages students in constructing mathematical knowledge enhances the development of mathematical power for all students of mathematics (Ball, 1993; Betke,
Mathematics educators have frequently been asked to change or modify teaching methods or content based on societal needs or new understandings of theories of learning in mathematics (Fullan, 1992; Shaw, 1992). The National Council of Teachers of Mathematics (NCTM) has actively promoted a vision of mathematics teaching and learning based on a more extensive definition of what it means to engage in learning mathematics. Imbedded in this vision is the belief that all students must be empowered mathematically to function productively in a technological society.

The need for a more developed and detailed explanation of what this change in mathematics instruction would look like has generated a number of publications over the decade of the 1980's. The textbook industry has actively engaged in revamping their materials to more accurately address a hands-on, problem-solving mathematics program. In 1987, California developed its framework for a model curriculum consistent with the forthcoming document from NCTM (California State Department of Education, 1987). Concurrently, the State Department of Education in Connecticut redesigned its mathematics guidelines for schools and developed a state test in mathematics aligned with these guidelines. These are a few examples of state generated efforts to reform mathematics education.

In 1989, the Curriculm and Evaluation Standards for School Mathematics was published by NCTM (National Council of Teachers of Mathematics, 1989). The standards, grounded in a constructivist framework called for students to experience mathematics in a manner consistent with the work of Dewey, Piaget, Vygotsky and others (Baroody, 1987; Baroody, 1990; Duckworth, 1987; Goldin, 1990; Harel, 1991; Labinowicz, 1985; Nicolopoulou,
The NCTM Standards, "grounded in more universal ownership than reform movements of the past" continues to encourage the educational community to rethink the school mathematics curriculum and to move toward the implementation of this reformed vision of school mathematics (Grouws, 1996, p. 443).

The standards document stimulated the rewriting of mathematics curricula across the nation. Educational publishers developed a number of new textbook editions and supplementary materials to address this approach to mathematics education (Burns, 1987; Burns, 1991; Burns, 1992a; Burns, 1992b; Countryman, 1992; Downie, 1981; Lesley College & TERC, 1989; Mathematics Education Development Center, 1990; Welchman-Tischler, 1992). In addition to the efforts of NCTM, Statewide Systemic Initiatives (SSI) and Urban Systemic Initiatives (USI) funded through grants from the National Science Foundation, have focused on comprehensive efforts to reform mathematics and science education. These efforts have promoted a move away from a conventional textbook-driven mathematics program to one that focuses on students' constructing mathematical meaning and understanding through active engagement with mathematical problem-solving situations (California State Department of Education, 1987; Lindquist, 1989; National Council of Teachers of Mathematics, 1989; Schifter, 1993; Sierpinska, 1993). These reform efforts are designed to encourage the development of "mathematical power" for all students of mathematics.

Mathematical power includes the ability to explore, conjecture, and reason logically; to solve nonroutine problems; to communicate about and through mathematics; and to connect ideas within mathematics and other intellectual activity. Mathematical power also involves the development of personal self-confidence and a disposition to seek, evaluate, and use quantitative and spatial information in solving problems and in making

21
decisions. Students' flexibility, perseverance, interest, curiosity, and inventiveness also affect the realization of mathematical power (National Council of Teachers of Mathematics, 1991, p. 6).


Implementing an innovative mathematics program that engages students in a dynamic problem-driven curriculum is the primary responsibility of the teacher. This responsibility is a difficult one for many teachers to address successfully (Simon, 1991). The work of Ball (1993) and Schifter (1992) state that many teachers at the early childhood and elementary levels do not see themselves as mathematically powerful. Generally, these teachers have been taught to view mathematics as a fixed body of knowledge and to engage in a didactic approach when teaching the subject (Ball, 1993). Elementary teachers frequently identify mathematics as their weakest subject (Ball, 1990; Schram, 1988). These issues must be addressed if teachers are to effectively implement this reformed vision of mathematics teaching and learning.

Teachers unfamiliar with a constructivist view of mathematics encounter difficulty implementing a program design based on a constructivist framework (Fosnot, 1989; Schifter, 1993; Simon, 1991). The problem is compounded further by the growing awareness among educators that many teachers themselves are fearful about opening up their mathematics program based on their limited procedural knowledge of mathematics (Eisenhart, 1993; Lindquist, 1989; National Council of Teachers of Mathematics, 1991). Lambert (1990) of the Elementary Mathematics Project at Michigan State University states:
In the classroom, the teacher and the textbook are the authorities, and the mathematics is not a subject created or explored. In school, the truth is given in the teachers' explanations and the answer book; there is no zig-zag between conjectures and arguments for their validity, and one could hardly imagine hearing the words maybe or perhaps in a lesson. Knowing mathematics in school therefore comes to mean having a set of unexamined beliefs (p.32).

Students denied the opportunity to engage in examining their mathematical beliefs are denied the opportunity to experience mathematical power.

Teachers Engaged in Reform

Several programs have been developed with support from the National Science Foundation (NSF) which promote more constructivist teaching and learning practices in mathematics. The SummerMath for Teachers Program at Mount Holyoke College engages teachers in intensive summer sessions that focus on mathematics education and teaching pedagogy. These sessions are followed by visits to teachers' classrooms during the school year to enhance the implementation of constructivist teaching practices. The SummerMath program is one of the first in-service programs to focus mathematics teaching on a paradigm grounded in constructivism (Betke, 1993; Grouws, 1996; Schifter, 1993; Simon, 1991).

The Center for Constructivist Teaching at Southern Connecticut State University is another site for constructivist preservice and in-service education (Fosnot, 1989; Schifter, 1993; Simon, 1991). A similar program takes place at Wesleyan University. The Wesleyan program initially focused on a group of twenty teachers from across the state. These teachers worked as a support system for mathematics reform within the state with increased responsibilities for in-service and staff development in districts.
A program developed at Bank Street College of Education in New York City is designed to engage experienced classroom teachers in a Master's Program in Mathematics Leadership. Teachers enrolled in the Bank Street program commit themselves to three summers of graduate work and ongoing project work during the intervening school years.

Each of these programs has contributed to a fuller understanding of the difficulties involved with "reconstructing mathematics education" (Schifter, 1993). The replication of programs like these is difficult because the level of funding necessary to carry out such programs is very high. One of the most expensive features of such programs involves on-going collaboration with teachers over time. For these reasons, programs that are often the most effective cannot be broadly replicated.

Individual school districts throughout the country have found it difficult to manage these financial and time intensive costs. Most school districts use in-house personnel to conduct in-service sessions. Teachers are often released from classes to engage in in-service education opportunities. The limited time and energy teachers can invest in such in-service is generally inconsistent with promoting a significant rethinking of their ideas about mathematics education (Fullan, 1992).

Publications from the National Council of Teachers of Mathematics and the National Research Council have been instrumental in addressing issues related to the professional development of teachers and in identifying the issues school districts and graduate teacher education programs must consider in their professional development programs for teachers both at the preservice and in-service levels.
Summary of the Review of the Literature

This review is representative of the major components of the literature related to the theoretical perspectives incorporated into the mathematics reform efforts. It is reflective of the changing reform efforts in mathematics education. These components, while addressed separately in this review, share a dynamic connection to one another. Each of these has influenced the others. The components taken collectively have had a powerful effect on creating opportunities for mathematics educators to engage in teaching and learning in mathematics in new ways.

The reform literature in mathematics education has engaged mathematics educators and teachers in a variety of models of in-service and preservice education consistent with the goals of reform. In this review I have focused on a number of broad based programs designed to support reform efforts in the teaching and learning of mathematics.
CHAPTER III

METHODOLOGY

Design of the Study

This study is designed as a qualitative study of a particular group of preservice teachers. The design utilizes a number of open-ended data collection strategies. These have been planned to engage the participants in actively reflecting on issues presented in their mathematics methods course and giving voice to these reflections. The data collected during the study includes questionnaires, in-depth journal entries, and small group interviews. The analysis of data occurs in a cyclical fashion. After identifying initial themes generated through the data, the data was re-examined to further corroborate the initial themes. Throughout the reporting of this study the voices of the participants involved in the study were used to validate the findings.

The Setting

The University of Massachusetts where this research was conducted is a major research state university located in a rural setting. The university draws a diverse group of students from a variety of socioeconomic levels. Students may select to enter one of the teacher certification programs offered at the School of Education at the beginning of the junior year. Current state certification guidelines require students to major in an academic discipline in order to receive certification as an early childhood or elementary teacher.

The program for preservice teachers is an intense one. Students are required to complete three supervised, field-based practica while enrolled in education course work. These practica are of increasing duration and complexity, as described below.
Initially, students are assigned to a classroom for one day a week as part of an introductory course to teaching. This initial placement is primarily an observational one. As students move through this placement, they begin to take on classroom responsibilities commensurate with their level of ability. Prior to the successful completion of this field experience, students are required to teach a class lesson in the setting. Supervision of the student is provided by the cooperating teacher and a university supervisor.

At the conclusion of this initial experience and upon the completion of the preliminary education coursework, students who wish to continue in the program must apply for admission to either the early childhood or elementary teacher certification programs. As part of the application process, students must submit a formal application and a portfolio of their work and experience with children. They then meet with two members of the appropriate programs for an in-depth interview.

Successful applicants to either program then begin two semesters of course work in education and related field experiences. Education majors are enrolled in mathematics and science methods classes during their first semester in the early childhood and elementary certification programs. Concurrently, students are placed in their second supervisory field experience. This field-based experience involves two full days a week in the classroom of a cooperating teacher. The student gradually assumes more and more responsibility within the classroom, especially in the areas of mathematics and science instruction. Supervision is provided by the cooperating teacher and through frequent observations and meetings with the university supervisor. These placements continue throughout the semester. Participants in this study were at this level of their education program.
Preservice teachers, generally during one of the semesters of their senior year, have completed their final practicum experience with a full semester of student teaching. This practicum consists of two placements of eight weeks each. Students seeking elementary certification have one placement at the lower elementary grades and the other at the upper elementary grades to address grade levels 1-6. For students seeking certification in early childhood these placements are in two classrooms at grade levels K-3.

The university also offers a Master's Program which leads to certification. Master's students may have had an education degree as an undergraduate or may have majored in an academic field. Depending upon their individual experiences, these students may engage in field work or they may not. All candidates in the Master's Program are required to take the education methods classes with additional requirements. Some of the participants in this study will be students in the Master's Certification Program.

Upon graduation successful candidates of these programs are certified by the State Department of Education. Graduates have secured teaching positions in a variety of settings in both the public and private sector.

The Participants

The participants in this study were 29 preservice teachers who had been accepted into either the Early Childhood Teacher Education Program or the Elementary Teacher Education Program. A small number of participants were students enrolled in the Masters in Education Teacher Certification Program. As in most education programs, the vast majority of these students were female. The group of participants reflected the diversity and variety of socioeconomic levels reflected in the general university population.
Undergraduate students enrolled in this course generally are about 20 years of age. There are frequently a few older undergraduate students in education classes. The graduate students enrolled in this course tend to range in age from 21 to 45. The following tables indicate specific information on students who chose to participate in the study. Table 1 identifies the undergraduate and graduate members of the study; Table 2 identifies the gender of the members of the study; and Table 3 identifies the specific education programs members of the study were enrolled in at the time.

Table 1

<table>
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<td>Graduates</td>
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Table 2

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<tr>
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Table 3

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<td>Early Childhood Ed.</td>
<td>7</td>
</tr>
<tr>
<td>Elementary Teacher</td>
<td>22</td>
</tr>
</tbody>
</table>

All students in enrolled in the Principles and Methods of Teaching Elementary School Mathematics were offered the opportunity to volunteer to participate in this study. An overview of the study was presented to students
and they were free to choose to participate or not to participate without affecting their involvement or grade for the course. I developed a consent form (Appendix A) consistent with the guidelines established by the Human Subjects Review Committee. Only data from students who agreed to participate in the study was used in the study. Every effort was made to assure the anonymity of the individuals involved in the study.

Course Description and Philosophy

The School of Education offers a number of programs for preservice teacher education. Two of those programs, the Early Childhood Teacher Education Program and the Elementary Teacher Education Program require preservice teachers to complete a course in mathematics pedagogy entitled Principles and Methods of Teaching Elementary School Mathematics. This course is taken concurrently with the science methods course. While enrolled in these courses students are engaged in a practicum experience. The instructor of the science methods class holds primary responsibility for supervision of this practicum experience.

The Principles and Methods of Teaching Mathematics in the Elementary School course has been designed to further the goals for the professional development of preservice teachers as outlined in the National Council of Teachers of Mathematics Professional Standards for Teaching Mathematics (1990). These goals, identified as standards, are grounded in specific assumptions. These assumptions have guided the design of the Principles and Methods of Teaching Elementary School Mathematics course.

1. Teachers of mathematics must have a thorough understanding of the curriculum standards put forth by NCTM (1989). The education of prospective teachers of mathematics should include "the development of the knowledge,
skills, understandings, and dispositions needed to implement the recommended standards."

2. Previous experiences in mathematics in school mathematics in college mathematics and experiences in field-based experiences have a profound effect on their understandings of what it means to teach and learn mathematics. These previous experiences must be challenged and discussed if prospective teachers are to explore new approaches to the teaching and learning of mathematics.

3. Learning to teach is a process that involves the integration of theory and practice. Preservice teachers must have opportunities to reflect on their learning in the classroom and in the field.

4. The ongoing development of a teacher is a continuous process that continues throughout one's career.

The standards put forth by NCTM for the professional development of teachers of mathematics are grounded in these assumptions. The standards state that professional teacher education programs must:

1. promote experiences which provide preservice teachers with opportunities to experience good mathematics teaching,

2. develop knowledge of the content and discourse of mathematics,

3. understand all students as learners of mathematics,

4. know mathematical pedagogy,
5. provide opportunities for teachers to examine, analyze, and evaluate their teaching of mathematics, and

6. take an active role in their ongoing professional development.

Courses designed to meet these goals dramatically differ from those of earlier programs. They differ in that they provide opportunities for preservice teachers to engage in thinking and learning about mathematics as members of a community of learners. In such communities the level of classroom discourse and the nature of that discourse enhance thinking about mathematics. Reflection on what has transpired in the classroom and on one's thinking about mathematics furthers the learning that has begun in the classroom. The mathematics classroom becomes a learning environment that supports individuals as they search for ways to model what they think or know to other members of the community. As individuals engage in sharing their ideas about mathematics, learning becomes a dynamic activity. Mathematics classrooms become learning communities designed to support the development of teachers of mathematics in the construction and reconstruction of mathematical knowledge.

Classrooms designed to enhance constructivist teaching practices provide powerful models for preservice teachers. Underhill (1991) identifies two layers of curricular interactions. One level of interaction focuses on teacher educators and teachers, the other focuses on classroom teachers and their students. He states:

It is my intention to make clear that success in constructing mathematical knowledge is greatly enhanced if these two layers of interaction are in epistemological harmony. That is to say, teacher education which is constructivist in its orientation is most likely to produce teacher-pupil
interactions which are constructivist in orientation. Another way of pointing to this need is to say that didactic or transmission models used to educate teachers about constructivist learning and teaching are incongruous (p.229)!

The models preservice teachers experience in their education programs have implications for how they will teach. Teacher educators in mathematics must build constructivist teaching practices into their courses with preservice teachers to increase the likelihood that these teachers will build such practices into their future work with students.

Data Collection Tools and Methods

Researchers have used a variety of modes of inquiry to study teacher beliefs. Richardson and Anders (1994) indicate that investigations into teacher beliefs and changes in beliefs and practice must include an open-ended, qualitative design rich in data collection. Holly (1989) identifies journal entries as a powerful tool in identifying teacher beliefs. In this study, I conducted an interpretative analysis of in-depth student journal entries as my primary source of data to address the research questions. Additional data included personal histories of preservice teachers' earlier mathematics experiences and small group interviews.

The tools used to gather data for this study included questionnaires, journal entries and semi-structured small group interviews. These tools were designed to provide insight into preservice teachers' thinking as they engaged in the Principles and Methods of Teaching Elementary School Mathematics course. Each of the tools included in the study used the voices of preservice teachers to personally identify their learning as they progressed through the course. The identities of the individuals were protected.

At our initial meeting, I asked students to respond to an open-ended questionnaire. (Appendix B) The questionnaire was originally designed by
Hal Melnick of Bank Street College of Education. In the questionnaire, students were asked to reflect on their elementary mathematics experiences. The following questions were presented in the questionnaire:

- What feelings did you develop in elementary school about yourself as a mathematically thinking person?
- What do you remember math lessons were like?
- What images are conjured up as you recall your teachers teaching you math?

Respondents were encouraged to include specific anecdotes if they recalled them. Finally, students were asked to find one word they would use to describe their memories related to mathematics. Students were given as much time to complete this form as needed. A copy of the form can be found in Appendix B.

A similar form was completed at the conclusion of the course. This questionnaire asked students to reflect on their experiences in the course. The questions on this second form asked:

- What feelings came up for you as you were doing mathematics in the context of this class?
- Describe what this mathematics learning environment was like for you?
- How do you think this experience will affect your teaching of mathematics with your future students?

Students were then asked to find one word to describe their experience in the course. This assignment was open-ended; students were told to take whatever time they needed to complete the form. A copy of this form can be found in Appendix C.

A second tool used in this study was student journal entries. At our first meeting I shared the assignments for the class. A major assignment was the
reflective journal. Students were encouraged to use this tool as a mechanism for continued learning beyond that which occurs within the classroom. Journals are powerful tools for thinking about what has gone on in the classroom, raising questions or dilemmas, and/or for additional insights into previous learning. Generally, students had no difficulty focusing on some aspect of their learning. Occasionally, students would ask for a topic to focus their journal entry on. I provided a series of questions for them to respond to. One of the questions I posed for students asked them to consider: What are you learning and how are you learning it? Students generally responded to entries that focused on new understandings they developed as a result of an exploration or discussion in class. I stressed that the journal was to be a personal learning tool for the student. I also stressed that the more honest and thoughtful they could be in their entries the greater the opportunity for learning on their part. Journal entries were required throughout the course.

My role as both the instructor and the researcher required another tool to add validity to the data previously generated. I decided to use semi-structured, small group interviews to address this. I developed a set of questions for students to respond to in groups of four or five. A colleague, not involved with the course, conducted these interviews. The interviews were taped and transcribed.

Data Analysis

The analysis of the data gathered in the course was occurred on multiple levels. The analysis follows the general design for qualitative studies. Richardson and Anders (1994) indicate that investigations into teacher beliefs and changes in beliefs and practice must include open-ended, qualitative design rich in data collection. In this study, I conducted an interpretive analysis of the data generated by students and supported these findings by
using the voices of participants in the study. Through analysis of these data, I identified emergent themes related to preservice teacher beliefs. I also hoped to illuminate teacher education practices which preservice teachers identified as having implications for increasing their opportunities to become agents of effective and dynamic change in mathematics teaching and learning.

Initially, the analysis began with a reading of student responses to the first questionnaire. This enabled me to identify the prior beliefs preservice teachers brought with them to the course. These responses were grouped into categories suggested by the data. These categories related to preservice teachers' understandings of themselves as learners of mathematics, as teachers of mathematics, and/or issues related to learning in general.

The next level of analysis involved the journal entries submitted by preservice teachers during the course. I began with a reading all of the data, marking sections which mention issues students had grappled with during the course. Information gathered through this initial reading was then coded and re-examined to identify themes related to beliefs reflected in the data. I was particularly interested in identifying data related to the prior beliefs previously examined, and any changes in these beliefs during their participation in the mathematics methods class.

Following the identification of emergent themes, I returned to the data to identify how the voices of preservice teachers validate the identified themes. The selection process was guided by the frequency of similar responses, depth of descriptive detail, and clarity. An additional reading of the complete data identified any material which might not have been caught in the initial reading. Any data which did not support the identified themes was noted. A similar process was utilized on the data gathered in the final questionnaire and through the transcripts of the small group interviews.
Finally, I returned to the data in an effort to identify any factors which preservice teachers identified that contributed to changes in their beliefs. Also noted were teacher education practices preservice teachers identified as having implications for increasing their opportunities to become agents of effective and dynamic change in mathematics teaching and learning.
CHAPTER IV

RESULTS AND DISCUSSION

This chapter presents the results and a discussion of those results using multiple perspectives: observation, dialogue, questionnaires, small group interviews, and journal entries. The results of the initial questionnaire included observational analysis of participants while they engaged in the process of generating data. Additional interpretation of these results continued through an on-going dialogue with participants as they strove to make that which is obvious to the reporter obvious to all. Finally, my role as the researcher required that I substantiate these early findings by re-examining the in-depth written responses to the questionnaire. The process of using multiple perspectives revealed different realities about participants' early experiences with mathematics. I believed that it was important to recognize and legitimize these multiple realities.

The results and discussion based on these data collection tools use multiple levels of interpretation for similar reasons. Lincoln and Guba (1985) state:

Naturalistic inquirers ... focus upon the multiple realities that, like the layers of an onion, nest within or complement one another. Each layer provides a different perspective of reality, and none can be considered "more true than any other. Phenomena do not converge into a single form, a single "truth," but diverge into many forms, multiple "truths" (p. 57).

The promotion of the use of journals in mathematics classes has increased dramatically over the past several years. Journal entries have been identified as a powerful tool in understanding student knowledge and beliefs.
In this study, preservice teachers kept weekly journal entries of their learning in the course. Their journal entries frequently focused on reflections of what had occurred in the mathematics classroom. The journals became a place to continue thinking about what had happened in class, a place to think about a different approach the preservice student might take, or possibly a place to question the teacher or one's cooperating teacher. The journal was a vehicle for learning. It was designed to continue the process of learning from one class to another.

Journals provided an opportunity for me to read, and in many cases discuss, specific journal entries with the writers. Reading the journals was a powerful experience. Students welcomed the opportunity to reflect on their thinking knowing that their thinking was valued. Their entries resound with vitality and honesty.

The analysis of the journal entries was cumbersome. I read each journal entry and coded the entries. I identified emergent themes that came from the journals. After reading a number of the entries, I began to see some patterns emerging. I continued to read the other journal entries with these themes in mind, and then returned to the earlier read entries to see if I had missed any references to the identified themes. I reread the entire set of journal entries to identify any new themes that I might have missed during the earlier reading. Based on this method, I identified five major themes that emerged from these data.

The themes addressed the beliefs and experiences preservice teachers brought to their mathematics classes as well as reconstruction of those beliefs and understandings as a result of their involvement in the course. They also identified new understandings about mathematical pedagogy that preservice teachers might use in their future teaching. Finally, they focused on the anger
participants were able to identify related to their previous experiences in mathematics. Once the themes had been identified, I returned to the journal entries to identify student entries that provided documentation for each of the themes. This task reaffirmed the categories I had identified and provided a wealth of personal documentation to support each of the themes. Information gathered through the questionnaires and the small group interviews provided additional support for these themes.

The following pages will elaborate on these themes in the following sequence:

- Prior beliefs and experiences about learning mathematics;
- New understandings about themselves as learners of mathematics;
- New learning about mathematical pedagogy;
- New or different ways of learning mathematics; and
- Anger about previous mathematics experiences.

These themes will be elaborated on using the voices of participants in the study. The voices used as quotations or comments in this section have been selected to support each of these themes and to reflect the diversity of the populations represented in these classes. I have selected the individual voices of preservice teachers to support these themes when they are representative of the voices of the larger group. Every effort has been made to include at least some comment or quotation from each of the participants in the study.

**Prior Beliefs and Experiences**

The first data collection tool used was an open-ended questionnaire. This pre-questionnaire asked participants to recall their memories of their
elementary school mathematics experiences. It posed a number of items for consideration: what were mathematics lessons like; what specific teaching practices can you recall; what images do you recall of your teachers teaching you mathematics; and what feelings did you develop in elementary school about yourself as a mathematically thinking person. A copy of this form can be found in Appendix B.

The initial findings generated from these data are the result of personal observation while the participants engaged in completing the questionnaire. The first finding reflected in the data indicated a high level of anxiety on the part of the participants. The process of completing the questionnaire generated anxious behavior for a majority of those involved. This was observed in their hesitation while getting started on the writing exercise. Comments heard included: "I can't remember that far back" and "I just can't remember". Other comments referred to the difficulty in remembering anything that had to do with mathematics. Another level of anxiety may have resulted from the novelty of the task. College students are not frequently asked to think about their earlier education and recall specifics of those experiences.

Encouraged to allow themselves to take some time to think about their early experiences with mathematics, these students began to recall specific experiences. Their level of anxiety diminished as participants began to remember their early experiences with mathematics, and they became more engaged in the exercise. They remembered teachers, teaching techniques, blackboard exercises, timed-tests, homework, times tables, etc. They also remembered many of the feelings that they had experienced about mathematics and about themselves as 'doers' of mathematics. These feelings were conveyed clearly and powerfully in their written statements.
The atmosphere in the classroom indicated a serious task was underway.

This writing process was a cathartic one for many of the participants. As they became more engaged in the process, their writing became more vivid and detailed. At the same time, I observed a real issue of privacy regarding their responses. Participants did not speak with one another as they completed the task; they reread what they had written and, in many cases, added additional information. They were very private about what they had written. I had the sense that they believed that no one else would have written anything like what they had written.

Following an adequate amount of time, I asked participants to wrap-up their writing and bring it to closure. As I said this, I could see the students visibly take hold of their papers. An air of resistance was building in direct relation to the potential possibility of asking for the papers to be handed in. When I asked them why they felt this way, I met the following responses: One student said, "I'll be found out." Another added, "Someone will know that I really am not ready to become responsible for teaching elementary mathematics." Another added, "This secret that I have clung to for so long may now be out for all to see." This general level of concern was also reflected in the overall silence in the room and panic on the faces of other students.

To dissipate this feeling of concern and anxiety, I asked students if they would share just the one-word response they had written at the bottom of the form. This is the one term they used to sum up their early mathematics experiences. I reminded them that their names would not be used. The twenty-nine terms generated in this session are reported in Table 4. The terms used are those generated by the participants and are arranged
randomly in order to minimize the potential for bias. Terms which were used by more than one participant are repeated in the data.

Table 4
Initial One Word Responses

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<th>stressful</th>
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</thead>
<tbody>
<tr>
<td>blah</td>
<td>interesting</td>
<td>work</td>
</tr>
<tr>
<td>boring</td>
<td>effective, but boring</td>
<td>bad</td>
</tr>
<tr>
<td>hell</td>
<td>vague</td>
<td>frustrating</td>
</tr>
<tr>
<td>stimulating</td>
<td>positive</td>
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<tr>
<td>yikes</td>
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</tbody>
</table>

The generation of the table had a very provocative effect on the group. They began to realize that they were not the only ones who might have had negative experiences or negative terms associated with their early mathematics experiences. A few participants found that they were in the minority because of the positive response they reported. In addition, some participants found that many of the one-word responses might have multiple interpretations or different words might convey the same meaning. This led to an interesting situation when the participants said they wanted to know more about these one-word responses.
I proposed developing a positive/negative continuum on which we could locate the terms. As a group, we generated the continuum. Some students wanted to elaborate on what they meant by their original response, but even with more information the location of the terms on the continuum barely changed. At the conclusion of this exercise, the continuum consisted of 90% of the 29 responses at or near the negative end of the continuum and 10% of the 29 responses at the positive end of the continuum. These results are presented in the Table 5.

Table 5

<table>
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<td>routine</td>
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An in-depth examination of these data provided through the pre-questionnaires presented a number of pertinent and poignant descriptions of prior experiences preservice teachers bring to their mathematics methods course. For example, one student, Narina, reported the following:

I can remember not knowing how to count past 100, or maybe it was just ten, but regardless of the number I was
I proposed developing a positive/negative continuum on which we could locate the terms. As a group, we generated the continuum. Some students wanted to elaborate on what they meant by their original response, but even with more information the location of the terms on the continuum barely changed. At the conclusion of this exercise, the continuum consisted of 90% of the 29 responses at or near the negative end of the continuum and 10% of the 29 responses at the positive end of the continuum. These results are presented in the Table 5.

Table 5

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<thead>
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<th>Continuum of One Word Responses</th>
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<tr>
<td><strong>positive</strong></td>
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<td><strong>negative</strong></td>
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An in-depth examination of these data provided through the pre-questionnaires presented a number of pertinent and poignant descriptions of prior experiences preservice teachers bring to their mathematics methods course. For example, one student, Narina, reported the following:

I can remember not knowing how to count past 100, or maybe it was just ten, but regardless of the number I was
confused, and I was afraid to ask how to do it because it was a test of some sort. I think back and now consider it ridiculous to give first graders tests on which so much anxiety is produced.

I always felt intimidated by times tables and can distinctly remember the day they were introduced...quite frankly, I think I was intimidated by all mathematical procedures.

Narina has clearly painted a vivid picture of what she remembered happened in her early mathematics experience. She has also linked that earlier experience with the sense of intimidation she felt when confronted with mathematical procedures. Look at the words Narina used to convey her ideas: "not knowing how", "confused, afraid", "anxiety", "intimidated". These are powerful words; they are words that have colored her sense of herself as a mathematically thinking individual. I would also say that they are already coloring her sense of herself as a teacher of mathematics.

Another preservice teacher, Chris, described the method of instruction she recalled most clearly:

I remember doing a lot of ditto sheets, and working on yellow sheets of paper from a math book. The only specific memory I have of math class was one from fifth grade. I had told my teacher I didn't understand the fractions we were working on, and she proceeded to embarrass me in class. She asked the class if they understood the material, telling them I didn't, saying it in such a way as to make me sound dumb, and then kept me in at recess.

Chris identified a number of practices she recalled most clearly. She remembered the ditto sheets, "a lot of ditto sheets." She remembered the "yellow sheets of paper from a math book." Most clearly, Chris remembered what happened when she "... told my teacher I didn't understand the fractions we were working on". What does Chris remember about sharing a lack of
understanding with her teacher? She remembered being embarrassed by the teacher. Chris goes on to say that her teacher made her sound "dumb."

Again, I must ask what message has this generated for Chris regarding her beliefs about mathematics learning and teaching?

Another student recalled her attempt at using a different approach to solving a mathematics problem for her teacher. She has strong memories of what happened to her whenever she decided to use her fingers to help with her calculations. Her memories of mathematics conjured up feelings going back to first grade. This student writes:

My memories of elementary math are not very good. Most of the teachers would explain something once and expect you to know it right away. They were upset if you didn't. I remember once in first grade we had to do a math bee. I had to do an addition problem, and I started to count on my fingers. The teacher yelled at me, and I was out of the bee. After that whenever we had math worksheets to do if she saw me use my fingers she took the paper away. Ever since then I've dreaded math. I remember throughout elementary school having to do problems on the board and not being able to sit down until it was solved and nobody was able to help you. Math was always frightening to me. I was always scared.

The words this student recounted have begun to sound familiar. Unfortunately, they are well represented in the collection of pre-questionnaires.

While the entries cited up to this point speak directly to the affective domain, many students also recall aspects of their early mathematics experiences that recall memories dealing with instruction and curriculum. The next student remembered learning multiplication tables. She remembered the method used to evaluate each student's progress in the classroom and the method the teacher used to report each student's progress. Listen as she shares her memory:
...In third grade we had to do multiplication sheets while being timed. For example "do as many problems as you can in 5 minutes." I hated that and would become a nervous wreck and then scores were always charted on the board which made it worse if you didn't do well. I have never felt successful in math.

Here is a student who can remember a lot of what math class was like. She also remembers a lot of what she felt in math class, too. The underlining in the quotation is that of the student. The last line in this part of her quotation also belongs to the writer. After several more years of mathematics experiences, this student writes, "I have never felt successful in math." This same participant continued to write about mathematics in fifth grade:

In 5th grade we studied decimal points, and % and I never quite got the hang of it. I think that I was afraid to ask questions. We always had to do problems and then bring them to the teacher's desk if we needed help.

In this student's memory I observed a move from feeling unsuccessful in third grade to deciding in fifth grade that it was too difficult to ask questions.

Another student writes about what she remembers as the routine for mathematics class, and clearly recounts how it all worked:

I really don't remember anything specific about learning math until the third grade. It was how we learned the multiplication tables. Every few days we were given a list of one of them, and we had to go home and memorize it. On the third day, we had to take an exam. If we passed it, we moved on to the next times table. If not, we had to keep taking that same test until we passed it. The way math was taught in my elementary school was through memorization and definitions. The teachers did a sample problem or two on the board, and then gave us several problems to do, many dittos, and we had workbooks. Every night we would have to do a page and turn it in the next day. We didn't really do or learn word problems or problem solving. We basically did straightforward problems. We learned multiplication, division, fractions, decimals, and percents. I wouldn't consider myself a
"mathematically thinking person," because all through school we really didn't have to "think" through a problem. We remembered the formula and did the problem. It was all computations.

This type of write-up documents what is encountered frequently in school mathematics classes. The procedural approach to mathematics is stressed, and it is what students learn. What happens to students who experience this approach to mathematics when they encounter a new problem or one they haven't seen previously? What do preservice teachers who are experienced in this approach do when they become responsible for the mathematics curriculum? According to the work of Underhill (1991), students who experience a procedural approach to their learning go on to use a procedural approach in their teaching.

This preservice teacher understands that a direct connection may exist between what happens affectively to a young student and what may or may not happen cognitively for the same young student. In this passage, we see a person who has developed an idea of "close" when it comes to mathematics. The "close enough" strategy works well for a good part of the time, but eventually the student begins to realize that there are times when it just doesn't do. I'll let the student tell her story:

I remember being in the car with my parents going on some day trip or something and practicing math. They would call out problems like 5+7 and I would ponder a minute and say 13. They would tell me the answer was 12, and I would reply I was close though. That sums up my theory on math. I was close enough. This made it tough later in life because with math most of the time close enough isn't good enough.

I also remember vividly 3rd grade...and the times tables. What stress. Every week a new times table would be memorized. At the end of the week individually we would go in the corner and be verbally tested. If you
passed, a sticker would be put on the chart next to your name; if not, it wouldn’t. There were many weeks that my row of stickers lagged behind the rest of the class. This just caused more stress and nervousness which made it harder to learn.

I was a very nervous child. I worried about everything. It seemed to me that math was a big worry because none of my teachers tried to make it less embarrassing and stressful. It’s hard to learn when you are nervous.

This preservice teacher has a real hold on something that may make her a better mathematics teacher. She realizes that being nervous or dealing with stress and/or an embarrassing situation may impede one's ability to learn. This is a powerful lesson for a beginning teacher.

The participants who responded with positive memories of their early mathematics experiences indicated an engaging atmosphere in the mathematics classroom. One student responded that even though his teacher did a lot of drill, there were other times when the teacher carried out a class project related to mathematics. Memories of those projects had generated a positive memory of elementary mathematics. Another student found the mathematics classroom "interesting." Further examination of this term indicated a real appreciation of the order of mathematics. This student liked the fact that there was always a right answer, and generally, she had it. (Since there were only two male participants in the study I feel it is important to note that one of the male participants reported a positive elementary mathematics experience, while the other reported a negative elementary mathematics experience.)

The analysis of the pre-questionnaire data which identified the prior experiences preservice teachers brought to the mathematics methods class supported what earlier research had stated. It also pointed out the overwhelmingly negative experiences most preservice teachers carry with
them into their teacher preparation courses. These negative experiences seemed to affect their attitudes about mathematics and about themselves as 'doers' of mathematics. These experiences also seemed to affect their interest in investigating mathematics and their abilities to do so. Even more significantly though, these early experiences may have fostered a negative disposition toward mathematics in these future teachers.

Understanding About Themselves As Learners of Mathematics

Reading the journals of students in this class revealed a number of new understandings they had established about themselves as learners of mathematics. It is important to recall that the group of 29 participants included only three individuals who had labeled their previous math experiences as positive. Students soon began writing about things that they were beginning to understand about mathematics. They began to describe how much more they felt they may have understood if teaching concepts rather than memorization had been the focus of their math lessons. Listen to these preservice teachers as they tell you in their own words about changes in their understandings about themselves as learners of mathematics.

Several students mentioned that their mathematics experiences lacked any real world application. During the course many of them began to see that building a connection between mathematics and the real world could help future students to become more successful problem solvers.

Before I took this class I had always learned about mathematics by learning an algorithm, memorizing it and repeating the procedure over and over again. I think that this semester I am learning that it's important for students to "discover" ways to solve problems through everyday situations and problems that arise. Learning and school should be related to everyday life, not a separate entity where facts are learned simply because the teacher says that it is important.
Other students talked about the new understanding they had for basic skills they had been using since elementary school, but with no understanding of why things worked the way they did. The following quotations are representative of the increased understanding participants mentioned in their journal entries. One preservice teacher wrote, "For years I have simply done it [multiplication and division] but never understood why or what I was doing."

Another wrote:

When I learned multiplication, I was given a list of a particular times table and was told to memorize it. I was never taught how the answers came about. I just learned the tables without knowing why. I never questioned this, because I thought that there wasn't an alternative way to learn multiplication.

One area that resulted in a great deal of reflecting involved concepts related to decimals, percents and fractions. Preservice teachers reported that they were beginning to see "concepts that were so complex and confusing to me are simplified and explained." Another student noted, "I am learning math myself. I am brushing up on my basic skills and working on things that I try to avoid as much as possible."

The following statements demonstrate how two students wrote about two very different aspects of the mathematics they were beginning to understand for the first time:

Last week's class was sort of like being back in elementary school again learning about fractions and decimals. The only difference between the two is that I learned more about fractions, decimals and percents than I did in all my years in elementary school."

Another piece of writing reflects a new sense of confidence as the preservice teacher considers applying her new understanding of concepts to her expectations for her students:
... it is important for children to learn to be able to decide when answers should be expressed in fractions, decimals, or remainders, or should be rounded up or down. When I learned about remainders, the only way I knew how to express it was because the teacher or the textbook asked for an answer to be expressed in a particular way.

As students began to experience a mathematics program built upon constructivist principles they began to construct their own understandings. "I am also really beginning to understand the power of estimation in real life. I guess I had never thought about it before. It is very clear that this is an important skill for children to learn." This comment was reiterated frequently, "Although there are times when I doubt my ability to do math, I feel far more confident in the subject than I ever have."

Overall, he preservice teachers participating in this study reported that they had increased levels of confidence in their abilities to learn mathematics. Over the course of the semester they developed new understandings of themselves as learners of mathematics.

**New Learning About Mathematical Pedagogy**

Preservice teachers engaged in learning about the principles and methods of teaching in mathematics must develop knowledge they can use in planning for learning in their future classrooms. Throughout the journal entries of these preservice teachers I found support for the theme of new learning concerning mathematical pedagogy. Many entries referred to something they had observed in class, observed in their practicum placement, or read about in one of the readings. One student noted "teaching mathematics takes a great deal of planning and a thorough understanding of math concepts." Many mentioned that mathematics classes should relate mathematics to real-life
situations. Others recognized the importance of presenting concepts in multiple ways:

I’ve noticed how important it is for students to have models for their learning. It makes things so much more real. I think it is also important to have these models because people learn in many different ways. Some people are able to just listen, picture things in their heads, and have concepts make sense. Others need visual clues, while others need the extra input of tactile reinforcement. ...Now I know that everyone learns in different ways, and as a teacher it is important to incorporate different teaching styles into my lessons to appeal to all types of learners.

These new understandings were sometimes based on personal experiences in the course. Others recognized them after reflecting on the limitations a particular learning style may have had on others:

When I was going through school, learning my multiplication tables and how to do division were purely a memorization process. I remember my mother drilling me every night. I never could quite grasp the meaning of why the answer was what it was, but lucky for me I had a pretty good memory. ...The whole process of moving from concrete materials to symbolization seems like such a natural process.

Statements like these provide encouragement to those engaged in preservice education, they indicate preservice teachers engaged in examining, analyzing and evaluating their teaching of mathematics. This practice is one to be encouraged.

One preservice teacher conducted her own limited research project when she recognized how many students reported limited experiences with fractions in elementary school. Her entry is lengthy, but it does convey how much thinking about mathematical pedagogy she was engaged in:

... Does this mean the average American elementary student learns of fractions in May or June when their
thoughts are elsewhere, or that time is running out in the academic year and the teacher must skim over the material? Perhaps the teaching of fractions is being shortchanged in our schools.

A brief survey of an all American family (mine) suggested just that. Fractions are tricky. You've got to deal with 2 numbers, the bottom number (denominator) and the top number (numerator). The bottom number throws you off--when it gets bigger, the fraction gets smaller. I decided to ask my family what they knew about fractions.

All four of us (husband, wife, 16 year old, and 11 year old) knew the definition of a fraction. We could define numerator and denominator. We were great with visualization techniques. Pizzas were the obvious choice. We could cut that pizza in half and subdivide. We could add, we could subtract (like denominators). We could translate into decimals. We could multiply--Could we multiply?--We could, but did we understand what was happening? Not really. Pens and notepads came out and by a process of elimination and with a little help from math methods, we understood the concept of multiplication and why things got smaller when you multiplied. The word used in class that was so helpful in teaching us the concept of multiplication was OF. (Not times.) \( \frac{1}{2} \) of \( \frac{1}{2} = \frac{1}{4} \) \( \frac{1}{2}/ \) of \( \frac{1}{3} = \frac{1}{6} \) We drew diagrams. O.K. So far, so good.

Now, the question of division. \( \frac{1}{3} \) divided by \( \frac{1}{2} \)? We all could do it. "Invert and multiply," \( \frac{1}{3} \) divided by \( \frac{1}{2} = \frac{2}{3} \)--but what are we doing? No one had a clue. After several diagrams of squares and pizzas, we reverted to my math methods notes and came up with the necessity of \( \frac{1}{2} \) becoming the whole. We would consider \( \frac{1}{2} \) to be our whole. In order for this to happen we need to multiply each side by \( \frac{2}{1} \). (What you do to one side you must do to the other.) The question was, how much of by \( \frac{1}{2} \) is going to be covered by my \( \frac{1}{3} \)? We finished the computation and got the result.

Doesn't it seem strange that 2 college graduates, a sophomore and a sixth grader didn't exactly know the concepts behind multiplication and division of fractions? This is arithmetic. Granted, my sample size was small, but, as a teacher, I still think I'm going to teach concepts and computation of fractions in October.
This preservice teacher is considering her future role as a mathematics instructor right now. She wants to plan what she can do to develop greater mathematical literacy in her future students.

**New or Different Ways of Learning Mathematics**

A third theme that was identified through the journal entries focused on new or different ways of learning mathematics. Students recognized that hands-on, activity based learning engaged them in more discussion and questioning as they worked on tasks. Most of the assignments completed in class were completed by using cooperative groups. The vast majority of students felt that these groups allowed them to become more involved in thinking about the task at hand. These strategies were strategies many participants mentioned as helpful in their own learning and something they would like to be able to incorporate in their future teaching. Participants also mentioned the use of a variety of learning models to better address the different learning strengths of students in their classrooms.

Connecting mathematics to the real-world was a theme that was repeated frequently. Many students identified the lack of any connection between what was learned in school and what was needed in the world. The following entry conveys one preservice teachers' thinking about new and different ways of thinking about teaching and learning mathematics:

>The question posed is, 'What are you learning and how are you learning it?' For me this is a very difficult question. At first I thought it was a busy work project. I thought for some time about this question, and realized it is a crucial question for a future educator. If I become accustomed to asking myself this question, I will be more apt to analyze how my students learn.

I have found that I learn by doing in this class. If you presented a method for teaching mathematics verbally only, I would not have such depth to my knowledge. Be allowing us to use our tactile senses and communicate our
ideas, we have a better understanding of the material and the method.

I am also learning by thinking about the methods in the book and presented in class. I have found myself analyzing if these would work in a classroom. I use my experiences to assess their appropriateness. In class, I can see the reactions of the other students to the lesson to help me gauge its effectiveness. So, by scrutinizing an activity or material I learn about it.

I am learning to think critically about the way children learn. I have found that I am beginning to assess every activity I read or do. I scrutinize my cooperating teacher and her methods of teaching math. I also have found that math teaching techniques are the first thing I look for when I observe a class. I know I can get much information from the work hung on the walls, and if they connect to children's lives and other areas of the curriculum. So, through this class I have changed my way of thinking. Before, I thought that math was an isolated subject that was predominantly based in the rote section of education. Now, I know there are better ways and I look at math instruction, and materials with a new perspective.

This class has taught me a lot. I appreciate the procedural knowledge because that is practical information I need to know. But to me, the new way of thinking about math instruction and materials is the most profound effect this class has had on me.

This student has developed the ability to think critically about mathematics and mathematical instruction. There is an awareness of how various learning styles can effect learning and how communication can improve and increase understanding. This preservice teacher has developed the ability to analyze situations from a different vantage point.

Anger About Previous Mathematics Experiences

This theme was the hardest for me to accept personally. I could not refute the data; preservice teachers were angry. They were angry about their earlier experiences in mathematics. This came through very clearly in their journal entries, but this theme came through even more powerfully in the small
group interviews. Preservice teachers discussed the opportunities they might have missed out on because they chose not to study mathematics-related disciplines. They talked about what their mathematics experiences could have been like if they had been taught in classrooms that used a more constructivist orientation. In the final questionnaire, a number of students talked about having missed out on what might have been. One commented, "I had a feeling of being cheated." They identified having felt cheated because of the limited approach to mathematics teaching they had experienced. They talked about how much more they could have learned if they had not been afraid to speak out; to say "I don't get it!" One participant said:

I never used manipulatives in grade school, and I'm wondering if I was an exception or if at the time many, if not most, schools didn't use them. I believe that if they had been used, my experiences with math might not have been so frightening.

Others wrote about their lack of understanding because they never understood the math concepts they had memorized. This is described in the final questionnaire write-up of one preservice teacher in this way:

This math experience has made a tremendous impact on my learning experiences. I used to believe that I was a good math student. Now, I realize that I had only memorized the ways to complete the problems. I had never understood what the numbers and formulas represented. Now, I have a better understanding of mathematics. I know what the numbers and formulas mean.

I was amazed, confused and then enlightened. My students will benefit from actively participating in the learning of mathematics for understanding.

Preservice teachers now felt that they could identify good mathematics teaching. When they compared what had happened in class with what had
happened in their previous experiences in learning mathematics they were
angry. One preservice teacher voiced this most effectively:

I felt some resentment toward my elementary school
teachers or maybe toward those who instructed them. For
the first time I enjoyed mathematics. I felt this classroom to
be a good place to rediscover and to learn math. For the
first time I realized that I was not dumb in math, but that I
was not instructed properly. I never was able to make
connections with math and other things but now I can.

The preservice teachers engaged in this course had come to a place where
they could recognize what had been denied them.

Classrooms designed to enhance constructivist teaching practices must
be models of constructivist teaching/learning practices. Underwood (1991)
suggests that preservice teachers who have opportunities to actively engage
in the construction and/or reconstruct on of their understandings of
mathematics and of themselves as mathematical thinkers are more likely to be
teachers who engage in constructivist practices with their students.
CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Summary of the Study

As a result of this study I have found that working with a relatively representative group of preservice teachers at a major university has produced results consistent with those generated by other studies that focused on a number of the issues addressed in this study. Some studies focused on developing the mathematics content knowledge of preservice teachers (Ball, 1990; Betke, 1993). Others have focused on developing the pedagogical knowledge of preservice teachers (Cobb, Wood and Yackel, 1990), while others have focused on the preservice teacher as learner (Confrey, 1994b, Melnick, 1992).

In this particular study I found that the vast majority of preservice teachers, when asked to recall their earlier mathematics experiences, use terms generally associated with negative rather than positive experiences. Some of the terms generated in this study included: "anxious"; "nervous"; "embarrassed"; "intimidated"; "afraid to ask questions"; etc. (See Table 5 for the complete listing.) Three of the twenty-nine participants used positive terms to describe their early mathematics experiences. This is consistent with the findings in Melnick's (1992) study.

The participants in my study had little difficulty in vividly identifying their early mathematics experiences and how those experiences had affected their beliefs about themselves as mathematically thinking individuals. Furthermore, these participants were able to identify specific decisions they had made as a direct result of their prior experiences in mathematics. One preservice teacher said she had selected early childhood as her certification area because she
understood math up to about the third grade. Other participants said they had selected courses of study that required a minimal understanding or knowledge of mathematics. They also reported that they made decisions to not ask for help from their teachers when faced with confusion or difficulty in mathematics.

Factors such as these have reassured me that it is imperative that we re-examine the preservice education of teachers of mathematics and commit ourselves to methods of instruction that take into account the realities of preservice teachers and the realities our programs of preservice education must consider if we are to develop teachers who are capable of promoting opportunities for powerful mathematics learning in their future students.

This study demonstrated that a course designed to promote constructivist learning practices enabled preservice teachers to begin the process of becoming more involved in their own learning. Preservice teachers had an opportunity to experience a mathematics classroom environment that challenged the traditional evaluative climate of most mathematics classrooms (Confrey, 1994). These preservice teachers began to experience a radical constructivist environment where "within the constraints that limit our construction there is room for an infinity of alternatives" (von Glasersfeld, 1990, p. 28).

Within such environments preservice teachers felt free enough to begin to reconsider their beliefs, understandings, and attitudes about mathematics. Preservice teachers discovered that: they began to think critically about modifications in instruction; they found themselves critically evaluating the cooperating teachers they were working with; they found themselves thinking about their mathematics program; and they found themselves engaged in thinking about mathematics as a dynamic and powerful subject.
With this freedom to reconsider their mathematics experiences, a significant number of preservice teachers also began to voice their anger at what had been denied them. These individuals were no longer going to listen to someone say they couldn't do it. They were not going to stop asking after the second or third time. These individuals have recognized some of the limitations they had chosen to live with because of the feelings they had about mathematics. They also have come to recognize that many of their feelings about mathematics had less to do with their abilities in mathematics, but had more to do with the way they were taught mathematics.

Recommendations for Mathematics Teacher Educators

A number of recommendations are listed here for teacher educators to consider while designing mathematics methods courses that better meet the needs of preservice teachers.

Reconnect to Previous Beliefs

Prior learning experiences in mathematics must be considered when designing courses for preservice teachers in mathematics. These experiences have a powerful influence on how preservice teachers perceive themselves as mathematically thinking individuals and as future learners and teachers of mathematics. Mathematics methods courses must promote opportunities for preservice teachers to reconnect to these prior experiences in mathematics in order to better understand how these experiences have helped to shape their beliefs about mathematics.

Promote Constructivist Classrooms

The results of this particular study further support research in the field which calls for classrooms designed to promote constructivist teaching and learning practices to maximize the opportunities for preservice teachers to engage in rethinking and reconstruction of previously held beliefs. In such
classrooms, the teacher assumes greater responsibility by assuring constructivist teaching opportunities consistent with preservice teachers' needs specifically in regard to authentic assessment of learner understandings and appropriate intervention based on these understandings. This is particularly important when we consider the two levels of interaction which Underhill (1991) believes teacher educators must address. He states:

> It is my intention to make clear that success in constructing mathematical knowledge is greatly enhanced if these two layers of interaction are in epistemological harmony. That is to say, teacher education which is constructivist in its orientation is most likely to produce teacher-pupil interactions which are constructivist in orientation. Another way of pointing to this need is to say that didactic or transmission models used to educate teachers about constructivist learning and teaching are incongruous (p.229)!

The models preservice teachers experience in their education programs have strong implications for how they will teach.

Create a Community of Learners

Beliefs must be challenged if future teachers are to engage their students in mathematics experiences that promote the development of mathematically powerful students. These beliefs can only be challenged in classrooms that encourage mathematical discourse and create places where students can experience a sense of personal responsibility for learning. Ball (1990) has concluded that teacher education programs must address the subject matter preparation of teachers. She states:

> Attending seriously to the subject matter preparation of elementary and secondary math teachers implies the need to know much more than we currently do about how teachers can be helped to transform and increase their understanding of mathematics, working with what they bring and helping them move toward the kinds of mathematical understanding needed in order to teach mathematics well" (p. 465).
The creation of a learning community would enhance preservice teachers learning of subject matter. In such communities students would engage in mathematics more closely by way of discourse and questioning. Confrey (1994a) states that this generates a shift in epistemological authority within the classroom. This shift engages preservice teachers in a more powerful and dynamic role in their learning of mathematics.

Utilize Resource Personnel

Preservice teachers need to be aware of resources that support them in their struggle to become more authentic teachers. They must locate those resources, use them, and get others to use them as well.

In today's world the use of the Internet is a marvelous tool to network with others to continue the dialogue that begins in a college classroom. Preservice teachers need to be aware of the resources they can access once they have left the environment of the college classroom.

Preservice teachers have a limited time to engage in an in-depth experience that provides the opportunity to challenge previously held beliefs about themselves as mathematically thinking individuals and about themselves as learners and teachers of mathematics. As one student reported:

The question posed is, 'What are you learning and how are you learning it?' For me this is a very difficult question. At first I thought it was a busy work project. I thought for some time about this question, and realized it is a crucial question for a future educator. If I become accustomed to asking myself this question, I will be more apt to analyze how my students learn.

Their learning and the methods used in that learning will affect the years of teaching their future students will experience. Teacher educators must make every effort to address teaching and learning strategies that encourage the
development and promote the ongoing development of teachers of mathematics.

**Suggestions for Further Investigation**

Additional studies designed to extend the work of this study might involve a longitudinal study of larger samples of preservice teachers, who had participated in a mathematics methods course that encouraged the reconstruction of beliefs about mathematics. Longitudinal studies would follow beginning teachers as they begin their professional teaching responsibilities and follow them for an extended period of time. Questions to be considered through such a study could focus on: How are teachers able to implement reconstructed beliefs in practice? How successful are these teachers in sustaining their beliefs in the classroom setting? What factors support the further development of teacher beliefs about mathematics teaching?

Additional investigations may help further our understandings of how prior beliefs can be identified earlier in the educational careers of our students. Can the identification of prior beliefs about mathematics among elementary students modify approaches to middle grades mathematics programs? How would understanding a young student's prior beliefs help to establish a classroom environment that would build on these experiences to enhance and foster the reconstruction of more powerful mathematical beliefs?

Another focus for future research may address the role parents of young children in our early childhood education programs play in establishing prior beliefs. Such research could identify hidden, non-verbal messages parents present to children concerning mathematics and their abilities to do mathematics. This could attempt to identify some of the ways that these messages are shared with young children. Do specific parental roles within the family affect the beliefs of young children? What effect do role choices
available to young children during playtime have on their construction of mathematical beliefs? What effect does toy selection have on the construction of mathematical beliefs?

In closing, research which focuses on preservice teachers and young students in our schools must be expanded to ensure that the vision of mathematics education available to our future students is one that promotes mathematical power for all.
APPENDICES
APPENDIX A

CONSENT FORM

IN THEIR OWN VOICE: A STUDY OF PRESERVICE EARLY-CHILDHOOD AND ELEMENTARY TEACHERS RECONSTRUCTING THEIR BELIEFS ABOUT MATHEMATICS TEACHING AND LEARNING

Consent for Voluntary Participation

I volunteer to participate in this study and understand that:

1. My journal entries and personal mathematics history response forms from my mathematics methods class will be used in this study. Excerpts may be used in the final document.

2. I will participate in small group interviews using a guided interview format developed by Barbara D. Henriques.

3. I understand that the primary purpose of this research is to identify emergent themes of pre-service teachers engaged in rethinking their understandings of mathematics and their roles as mathematics teachers. The results of this study will inform teacher educators of pre-service mathematics methods courses.

4. My name will not be used, nor will I be identified personally in any way or at any time. I understand that it will be necessary to identify participants in the dissertation as preservice teachers at the University of Massachusetts.

5. I may withdraw from part or all of this study at any time.

6. I have the right to review the findings of this study prior to Barbara Henriques' final oral exam. I will inform Barbara Henriques if I choose to exercise this right and keep her informed of any change of address.

7. I understand that the results of this study will be included in Barbara D. Henriques doctoral dissertation and may also be used in manuscripts submitted to professional journals for publication and/or professional presentations.

8. I am free to participate or not to participate without prejudice.

Researcher ___________________________ Date ____________ Participant ___________________________ Date ____________

Address ____________________________________
APPENDIX B

PRE-QUESTIONNAIRE

PRINCIPLES AND METHODS OF TEACHING
MATHEMATICS IN ELEMENTARY SCHOOLS

Instructor: Barbara Henriques       Course # ED 463

Name: ____________________________ Phone ____________

Early Childhood _______ Elementary Teacher Ed _________

Tier II Placement __________________ Grade level ______

Please take about five to ten minutes to record any memories you have about your elementary school mathematics experience. Consider the following:

What feelings did you develop in elementary school about yourself as a mathematically thinking person?

What do you remember math lessons were like?

What images are conjured up as you recall your teachers teaching you mathematics?

Include specific anecdotes if you recall them. Feel free to go onto the back of this sheet.

What one word would you use to describe your math memories?
APPENDIX C
POST-QUESTIONNAIRE

PRINCIPLES AND METHODS OF TEACHING
MATHEMATICS IN ELEMENTARY SCHOOLS

Instructor: Barbara Henriques        Course # ED 463

Name: _____________________________ Phone __________

Early Childhood _______ Elementary Teacher Ed _________

Please take a few minutes to reflect on the experience you have had in this class this semester. Consider the following:

What feelings came up for you as you were doing mathematics in the context of this class?

Describe what this mathematics learning environment was like for you?

How do you think this experience will affect your teaching of mathematics with your future students?

Use specific examples whenever possible.

What one word would you use to describe this math experience?
APPENDIX D

COURSE SYLLABUS

EDUC 463  Principles and Methods of Teaching Elementary School Mathematics

Instructor: B.D. Henriques
Course Syllabus

Text Materials

The textbooks required for the course are available at the Jeffrey Amherst College Bookstore. They are listed under the course number with other UMass course materials.

The textbooks for the course:


Course Requirements

Journal: A major learning tool in this course is the journal that you will keep throughout the semester. This will probably be the first time you’ve kept a journal in a mathematics class, the Countryman text will be helpful to you in more fully understanding what a journal in a mathematics class might be like.

Generally, the journal will be your place to reflect on the learning that has occurred during the class or while studying material in the texts. It may also be used as a place to discuss what you see happening in your cooperating teachers classroom. Hopefully, before the semester is out your journal will also include reflections on a lesson you’ve been able to plan and teach to your students.
I will correspond with you via the journal. Don't hesitate to raise questions or concerns you may have. If I feel it might be helpful to meet with you to provide more in-depth feedback I will ask you to set up a time to meet with me.

Journal entries are to be handed in at the beginning of each class. I would prefer that they be done on a computer or word-processor of some kind, but I will accept hand-written entries (as long as I can read them).

Occasionally, I may ask that all students write about a particular topic or question. The question you will hear asked most frequently will be: What are you learning and how are you learning it? It's one I would encourage you to ask yourself before you begin each entry.

**Critiques:** During the semester you will be asked to complete six critiques of articles from current mathematics journals. Student subscriptions are available to the NCTM journals at a special price of $8 for the semester. Contact me if you'd like to order this journal for the semester. The journal can also be found in the library. The format for each critique should include:

<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Journal</th>
<th>Edition</th>
<th>Pages</th>
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</thead>
</table>

**Critique:** You may need to provide a brief summary of the article--brief is the word to remember. Following the brief summary you should write a concise critical review of the article. Concentrate on what the content of the article is. Does the article describe something that could be used in your future classroom? Why, why not? What issues does the article raise?

**Portfolio:** During the semester you will be responsible for developing a Mathematics Portfolio that follows the format of the NCTM Standards. Using a variety of resources, including those available from your cooperating teachers, you will develop or select two activities which address a Standard. Whenever possible your activity should address more than one of the Standards. We will discuss this in greater detail during the course and closer to the time to begin working on the portfolio I will bring in a model and detailed outline to guide your portfolio development.

**Class Participation:** The duration of each class session is two and a half hours. This is a long period of time to be in one class, but it also means that we will have the opportunity to deal with hands-on activities that promote learning mathematics and how to teach mathematics to young people.

Your full participation is required and expected at each class. Periodically we will work in cooperative groups, pairs, etc. Each person in these groups is required to fully participate in the generation of ideas, the proving of ideas, and the drawing of conclusions.
# EDUC 463
## Class Schedule

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<thead>
<tr>
<th>Session One</th>
<th>Class Organization and Overview</th>
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<tbody>
<tr>
<td></td>
<td>Previous Mathematics Experiences Activity</td>
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<td></td>
<td>The NCTM Standards</td>
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<td>Meaningful Mathematics (Building a rich problem solving environment in the classroom.)</td>
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<tr>
<td>Session Two</td>
<td>The History of Mathematics Reform in the US</td>
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<td>The Process Standards</td>
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<td>Session Three</td>
<td>The Three Major Strands of the Mathematics Curriculum: Data Analysis, Number Concepts, and Geometry</td>
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<td>Linking The Strands to the NCTM Standards</td>
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<td>Session Four/Five</td>
<td>Patterns and Relationships</td>
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<td>Arrays for Multiplication and Division</td>
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<td>Number Sense and Numeration</td>
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<td>Concepts of Whole Numbers</td>
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<td>Whole Number Operations</td>
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<td>Fractions, Decimals and Percents</td>
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<td>Session Six/Seven</td>
<td>Geometry and Spatial Sense</td>
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<td>Geoboards and Tangrams</td>
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<td>Area and Perimeter Problems</td>
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<td>Session Eight</td>
<td>Using Literature to Teach Mathematics</td>
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<td>Session Nine</td>
<td>Assessment in Mathematics</td>
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<td></td>
<td>How do we measure what we know?</td>
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<td>Is there a difference between evaluation and assessment?</td>
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<tr>
<td>Session Ten</td>
<td>Thematic Teaching</td>
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<td>Finding the Mathematics in the Theme vs. Making Mathematics Fit the Theme</td>
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<td>Mathematics As a Cultural Tool</td>
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<tr>
<td>Session Eleven</td>
<td>Visiting Mathematics Classrooms</td>
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<td>Evaluating these classrooms</td>
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Session Twelve  Available Mathematics Materials
How to Modify Materials
Building a Support Network for Mathematics

Session Thirteen  Issues of Equity in Mathematics
Robert Moses
Educational Equity Concepts

Session Fourteen  What have you learned and how have you learned it?
Small group discussion followed by large group sharing.

Where do we go from here?
REFERENCES


Piaget, J. (1963b). The psychology of intelligence. Patterson, NJ.


