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PRESERVICE TEACHERS' BELIEF SYSTEMS AND ATTITUDES TOWARD MATHEMATICS IN THE CONTEXT OF A PROGRESSIVE ELEMENTARY TEACHER PREPARATION PROGRAM

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ABSTRACT

Most teacher education programs have, in one form or another, goals that are related to student beliefs regarding teaching and learning. The effectiveness of the teacher education curriculum in reaching these goals will be mediated by the student's initial belief systems and the beliefs they develop throughout their programs of study. For this reason, it is important to gain a greater understanding of the beliefs of prospective teachers at various points in their development as teachers. The current study focused on one teacher education program and one subject area, mathematics, within the elementary education curriculum in that program. The study was designed to answer three research questions: What are the attitudes and personal, pedagogical, and epistemological beliefs about mathematics held by preservice elementary and early childhood teachers before, during, and after completion of teacher preparation coursework; what are the relationships among theses beliefs and attitudes; and, do these beliefs and attitudes differ as a function of the prospective teachers' educational experience.

Participants (N=226) in the sample were undergraduate and graduate students enrolled in the elementary education program at a large Southwestern university. Fifteen sections of six different classes were surveyed over a three semester period from the fall of 1998 to the summer of 1999. Participants were organized into five groups based on teacher education experience.

Participants completed an 83-item Likert scale questionnaire in either a freshman level mathematics class, an educational psychology class, or a mathematics methods class. Multivariate Analysis of Variance statistical tests were used to examine all five groups over the nine subscales of the questionnaire. Regardless of the semester, instructor, or course, the trend was clear. Students who had participated in the elementary teacher education program held significantly different beliefs than those who had not.

By the time the preservice teachers had completed the elementary education coursework, they had significantly higher self-efficacy with respect to their ability to effectively teach mathematics. These students also reflected a strong adoption of the National Council of Teachers of Mathematics Standards (1989, 1991) recommended constructivist orientation toward teaching mathematics. Finally, these students showed a sophisticated epistemological view on the nature of mathematics as a dynamic, ever changing, problem driven branch of science.

Chapter I

INTRODUCTION

Background of the Study

Understanding teachers' beliefs and their impact on educational behaviors in the mathematics classroom is an important and complex undertaking (Ernest, 1989, Pajares, 1992). Because different beliefs interact with one another in complex ways, clusters of beliefs are formed. Therefore, according to Pajares (1992), it is necessary to examine beliefs as a holistic organization of interactions. This interactive organization of beliefs is often referred to as a teacher's "belief system".

Researchers have illustrated the connection between a person's personal belief systems (such as self-efficacy and outcome expectations) and the decisions they make about the behaviors they display (Bandura, 1977, 1986). The relationship between the belief systems of teachers and student teachers, including attitudes, efficacy beliefs, pedagogical beliefs, and motivation, and their behaviors in the mathematics classroom has been the focus of many researchers (Ball, 1990, Borko, Eisenhart, Brown, Underhill, Jones, & Agard, 1992, Curda, Curda, & Miller, 1996, Fleener & Nicholas, 1994, Nicholas & Fleener, 1994). The behaviors examined have included topics such as how lessons are designed, the way the material is presented, and the time spent on the material. These teaching behaviors, as they relate to how mathematics material is taught, are a major concern addressed by the National Council of Teachers of Mathematics (NCTM, 1989, 1991). Of course, the mode of presenting material varies among teachers based on a variety of issues besides their belief systems. These issues include pressure from administrators, experience, and interest (Eisenhart, Borko, Underhill, Brown, Jones, & Agard, 1993, Smith, 1996). However, the strong relationship between teacher behaviors in the classroom and their belief systems is still cited as an important issue in need of much research (Ernest, 1989, Fleener & Nicholas, 1994, Pajares, 1992).

Because teachers' belief systems can affect their planning and preparation in the classroom, student motivation and achievement is impacted (Midgley, Feldaufer, & Eccles, 1989). Teacher's beliefs and behaviors have also been shown to impact students' comprehension of mathematics, especially with respect to conceptual understanding (Carpenter, Fennema, Franke, 1996, Fuchs, Fuchs, Karns, Hamlett, Durka, & Katzaroff, 1996, Stipek, Salmon, Givin, & Kazeni, 1998).

In summary, many researchers have argued that teacher held beliefs impact the choice of actions and behaviors related to their instructional techniques in mathematics (Ernest, 1989, Foss & Kleinsasser, 1997, Raymond, 1997, Smith, 1996). These choices have a direct relationship to student achievement in mathematics (Ball, 1990; Fuchs, Fuchs, Karns, Hamlett, Durka, & Katzaroff, 1996; Hiebert, Wearne, 1992).

Many teacher preparation programs have acknowledged the importance of teacher beliefs as they impact classroom behaviors. Thus, one of the goals of some teacher preparation programs is to promote critical thinking among prospective teachers which allows them to reflect on a coherent philosophy of what is effective instruction and their ability to implement it (e.g., see the University of Oklahoma Curriculum Folio for Elementary Teachers, p. 2-3). Other teacher preparation programs have explicitly included attitudes and beliefs such as efficacy as a part of their curriculum (McDevitt, Heikkinen, Alcorn, Ambrosio, & Gardner, 1993). Still others have tried to assess the extent to which individual courses and field experiences have affected preservice teacher's beliefs (McDiarmid, 1990; Vinson, 1995).

Given the research on the impact of teachers' beliefs on their teaching and the desire of teacher education programs to try to influence (explicitly or implicitly) prospective teachers' beliefs about what is effective instruction and their ability to implement it, it is important to understand what beliefs preservice teachers hold as they prepare to enter the profession.

Significance of the Study

Most teacher education programs have, in one form or another, goals that are related to student beliefs regarding teaching and learning. Some programs explicitly attempt to influence their students' beliefs about the most appropriate methods of teaching and the most appropriate models of student learning. Others explicitly attempt to strengthen their students self-related beliefs (self-efficacy) regarding teaching. Still others attempt to foster critical thinking and reflective practice among their students. In all these cases, the effectiveness of the teacher education curriculum in reaching these goals will be mediated by the student's initial belief systems and the beliefs they develop throughout their programs of study. For this reason, it is important to gain a greater understanding of the beliefs of prospective teachers at various points in their development as teachers.

Purpose of the Study

To begin this process of understanding prospective teacher beliefs, I focused the current study on one teacher education program and one subject area within the elementary education curriculum in that program. The purpose of this study was to examine the attitudes and beliefs of prospective teachers at several points in the educational process. The beliefs examined included preservice teachers' epistemological views about the nature of mathematical knowledge, their views about what is effective instruction in mathematics, and their views on their own ability to implement effective mathematical instruction.

The hope is that a comparison of the beliefs of preservice teachers at different points in their educational experience may reveal some insights as to the evolution of belief systems and attitudes. An understanding of the dynamics of belief systems may be one more factor contributing to the development of prospective teachers who approach the teaching of mathematics with positive attitudes toward mathematics, who feel efficacious about their ability to implement effective instructional techniques, and who can reflect critically on their beliefs about the different orientations to teaching mathematics at the elementary level.

Research Questions

The objective of this study is to investigate the following research questions:

1. What are the beliefs about mathematics held by preservice elementary and early childhood teachers before, during, and after completion of teacher preparation coursework?
   - (i) What are their personal attitudes toward mathematics?
   - (ii) What epistemological beliefs do they hold about the nature of mathematics and how it is learned?

(iii) What pedagogical beliefs do they hold about what is effective instruction in mathematics?

(iv) what efficacy beliefs do they hold with respect to their ability to become effective mathematics teachers?

(v) What expectations do these preservice teachers hold with respect to their teacher preparation program's ability to prepare them to implement effective mathematics instruction?

2. What are the relationships among the attitudes and personal, pedagogical,and epistemological beliefs at each of four levels of the teacher preparation program?

(i) For students who are just beginning their teacher preparation program and who have experienced little or no formal teacher preparation training, what are the relationships among:

   a. personal attitudes about mathematics
   b. beliefs about how mathematics should be taught
   c. beliefs about the nature of mathematics
   d. personal self-efficacy beliefs in their ability to become effective mathematics teachers and to implement effective mathematics instruction
   e. expectations about their teacher preparation program's ability to prepare them to implement effective mathematics instruction

(ii) For students who are early in their teacher preparation program and who have completed at least one class in some formal teacher training area, including, but not limited to, professional education courses and/or mathematics methods courses, what are the relationships among:

   a. personal attitudes about mathematics
   b. beliefs about how mathematics should be taught
   c. beliefs about the nature of mathematics

d. personal self-efficacy beliefs in their ability to become effective mathematics teachers and to implement effective mathematics instruction
e. expectations about their teacher preparation program's ability to prepare them to implement effective mathematics instruction

(iii) For students who are midway through their teacher preparation program and who have completed at least one professional education course and part of their mathematics methods training, what are the relationships among:

a. personal attitudes about mathematics
b. beliefs about how mathematics should be taught
c. beliefs about the nature of mathematics
d. personal self-efficacy beliefs in their ability to become effective mathematics teachers and to implement effective mathematics instruction
e. expectations about their teacher preparation program's ability to prepare them to implement effective mathematics instruction

(iv) For advanced students who have completed all professional education courses, all mathematics methods coursework, and all associated field experiences except student teaching, what are the relationships among:

a. personal attitudes about mathematics
b. beliefs about how mathematics should be taught
c. beliefs about the nature of mathematics
d. personal self-efficacy beliefs in their ability to become effective mathematics teachers and to implement effective mathematics instruction
e. expectations about their teacher preparation program's ability to prepare them to implement effective mathematics instruction

3. Do the patterns of relationships among the attitudes and personal, pedagogical, and epistemological beliefs of students at the three levels of the teacher preparation program differ?

Chapter II

Current Literature

An important goal of the current study was to examine the beliefs held by prospective teachers about what is effective teaching and their ability to implement it. In order to determine what beliefs were relevant, it was necessary to first examine the literature on both preservice teachers' and practicing teachers' beliefs about effective teaching and its implementation.

According to Pajares (1992), understanding teachers' beliefs and their impact on educational behaviors is an important and complex undertaking. He called this a "messy construct" and pointed out the need for some consistency of terminology among researchers in this area. In his synthesis of the literature, Pajares indicated that several different terms are used for the construct. These terms include: perceptions, values, attitudes, beliefs, belief systems, and many more. Pajares stated that, for the research on teachers' beliefs to have viability, specific beliefs must be "clearly operationalized", as well as "appropriate methodology chosen, and design thoughtfully constructed" (p.308).

In addition, Pajares (1992) argued that a key problem in defining teachers' beliefs comes in separating beliefs from knowledge. Therefore, these constructs, when referred to in the current study, have been classified into three categories: Knowledge, beliefs, and affect.

Following a common convention, in the present study beliefs have been distinguished from knowledge by way of valuation (e.g. see Pajares, 1992 review of literature; Ball, 1990; Ernest, 1989). Beliefs are those statements concerning objects, events, actions, or relationships (cognitive schemata) that an individual holds to be true. These tend to be idiosyncratic and vary among the relevant population. Because of this variance, these cognitive schemata have an evaluative or judgmental component. Knowledge, on the other hand, has a more stable quality across populations. It tends to be more universal in nature and less variable among the relevant population. However, note that beliefs are distinguished from knowledge in that we do not necessarily believe everything that might be considered common knowledge. Thus what we believe to be true probably has greater impact on our choices and behavior than our accumulated bits of knowledge. In addition, widely held beliefs may often be classified as knowledge. For example, the belief that the Earth was the center of the universe was a widely held belief by Biblical scholars of the middle ages. This was accepted as scientific fact, and mathematical evidence to the contrary was given little or no credence. Therefore, for the current study, the variance of statements among individuals which are held to be true is what will distinguish beliefs from knowledge. In other words, when a statement can be agreed with or disagreed with to some extent it has measurability and is considered a belief.

In addition, certain cognitive schemas may have an affective component, whereas knowledge, as well as some beliefs, may be generally viewed as neutral and impartial. When the cognitive schema a person holds to be true contains an affective component, somewhat different labels are often used. Attitudes, opinions, value judgments, and certain emotions (such as shame, pride, and guilt) might fall into the category of affective schemas. Undisputed facts (such as historical dates or multiplication tables) and algorithms would be classified within the realm of the impartial knowledge construct. Such affective schema as a positive attitude, "liking" or "disliking", a sense of enjoyment, pride in accomplishment, lust for excitement, or fear of failure may well override knowledge when individuals make decisions or choices related to certain behaviors or choices (Csikszentmihalyi & Nakamura, 1989). It is difficult to distinguish whether this affective component of cognition may be a by-product of beliefs or somewhat separate from beliefs. However, for the current study, when statements have both an evaluative and affective component, I have classified these statements as "attitudes".

Thus we see that the constructs of attitude, belief, and knowledge may overlap and interact in a complex way to form cognitive systems which impact behavior. Many researchers

(Ball, 1990; Ernest, 1990; McDevitt, Heikkinen, Alcorn, Ambrosio, & Gardner, 1993; McGinnis, Watanabe, Shama, & Graeber, 1997) agree with Pajares (1992) that an understanding of the attitude and belief components of this complex cognitive system in teachers and prospective teachers is essential to improving their professional preparation.

Because different beliefs and attitudes interact with one another, clusters of beliefs are formed. Pajares (1992) stated that a holistic organization of interacting beliefs is often called an individual's "belief system". Thus, in the present study, the term "belief system" has also been used to indicate several beliefs and attitudes which interact together and may be very difficult to tease apart. Indeed, in trying to separate some of these beliefs, one may compromise the complete picture. The assumption is made here that belief systems, not just singular beliefs, work to affect behaviors and judgments in preservice mathematics teachers.

The current study investigated five variables related to the belief systems of preservice elementary mathematics teachers. These include: (a) attitudes toward mathematics, (b) efficacy issues about learning and implementing effective instructional strategies, (c) expectations (both at the personal and general professional levels), (d) epistemological beliefs about the nature of mathematics and how it is learned, and (e) pedagogical beliefs about how mathematics should be taught.

The reason for examining these particular beliefs held by preservice teachers is found in theory and empirical evidence relating to their choice of actions and behaviors when learning about effective instructional techniques and how to implement them (Ball, 1990; Bandura, 1977, 1986; Ernest, 1989; Foss & Kleinsasser, 1997; Raymond, 1997; Schommer, 1994; Smith, 1996). The importance of the choices of instructional techniques and classroom behaviors by teachers has been examined by many researchers. Relationships have been found between teachers' instructional techniques and classroom behaviors with students' attitudes, motivation, achievement, and conceptual understanding (Carpenter, Fennema, & Franke, 1996; Fennema, Carpenter, Franke, Levi, Jacobs, & Empson, 1996; Hiebert & Wearne, 1992; Midgley, Feldaufer, & Eccles, 1989; Stipek, Salmon, Givin, & Kazeni, 1998). Thus it seems important that prospective teachers develop an understanding of what is an effective instructional strategy and develop efficacious beliefs about their ability to implement it. Teacher education programs would seem to be the obvious vehicle for enhancing the development of these attitudes and beliefs. Earnest (1989) has summarized this in the following statement:

> This analysis of the beliefs and attitudes of the teacher of mathematics raises a number of questions: To what extent do a teacher's attitudes and beliefs affect their teaching of mathematics?... What are the effects of teacher education courses on teachers' attitudes and beliefs? (p. 27).

In an attempt to address the question of the effect of teacher education programs on preservice teachers' attitudes and beliefs, McDevitt, Heikkinen, Alcorn, Ambrosio, & Gardner (1993) cited teacher attitudes as an important contributor.

They stated that "teachers' attitudes toward science and mathematics represent a critical influence on their instruction in these subjects" (p. 594). The researchers further indicated that teachers' attitudes could affect the amount of time spent in teaching the subject and the methods that were used in the classroom. Thus it is important to develop positive attitudes in prospective teachers.

In their longitudinal study at the University of Northern Colorado, McDevitt and her colleagues (1993) examined a model program for elementary mathematics and science teachers. The aim of that program was to enhance preservice teachers' ability to teach science and mathematics. The major goals of the program were to increase students' understanding of how to implement effective hands-on strategies in instruction and to foster efficacy and positive attitudes toward the teaching of mathematics and science.

McDevitt et al. (1993) found a significant change in preservice teachers' attitudes and beliefs over the two-year course of study. In addition, they found significant differences between the treatment groups and control groups. The program involved two different cohorts of preservice elementary teachers and two longitudinal control groups.

Participants in the study (McDevitt et al. (1993) consisted of 65 undergraduates who were seeking elementary teaching certification in the first cohort. Sixty-one participants enrolled in the second cohort. These participants indicated they were not necessarily interested in pursuing mathematics or science as a field of study, but wished to learn how to become effective teachers in those areas. Applicants for the program were selected for the cohorts on the basis of essays on request forms. At several points during the study, each cohort was compared against both longitudinal control groups and course control groups. The two longitudinal control groups consisted of 60 undergraduates in each group who entered the university at the same time as the comparative cohort students and were also seeking elementary certification, but who did not enroll in the same programmed course of study. Course control groups consisted of students taking a similar course, but not in the cohort program.

The program was conducted by university faculty and experienced elementary teachers working together to train the preservice teachers in the areas of science and mathematics. Because this was a sequenced set of nine courses, instructors were able to build on concepts from previous courses and integrate material across the curriculum. For example, science courses could use specific concepts taught in the previous mathematics course. The focus was to build integrated knowledge and to cultivate efficacy and positive attitudes toward mathematics and science.

McDevitt and her colleagues (1993), obtained information on participants' attitudes and beliefs through a series of self-report questionnaires administered to both the control and participant groups before and after the program. The questionnaires were modifications of the *Fennema-Sherman*

Mathematics Attitude Scale (Fennema & Sherman, 1976) as well as items developed by the researchers. Students' beliefs about desirable characteristics for teaching were assessed through open-ended questions about the types of knowledge, skills, and understandings that they believed were necessary for effective elementary teaching.

Using a series of t-tests on the attitude variable, the researchers (McDevitt et al., 1993) found no significant difference between program participants and control groups at the beginning of the study. However, an Analysis of Covariance (with the original attitude scores as the covariant) revealed a significant difference at posttest. Results of this study indicated that program participants had more positive attitudes toward teaching mathematics and science than the control groups. Their perceptions about teaching showed an integration of understanding the value of conceptual learning and hands-on applications for teaching and learning mathematics and science. These attitudes and pedagogical beliefs about the teaching of mathematics were also the focus of a series of studies conducted in Maryland over the last several years.

McGinnis et al. (1998) reported a longitudinal study in which the change in teacher candidates' attitudes and beliefs about the nature and teaching of mathematics and science was charted. Participants in this study were involved in a specially designed program for the Maryland Collaborative for Teacher Preparation (MCTP). This program included five higher education institutions within the University of

Maryland System which participated fully in the completed study.

The research question addressed by this study was whether enrollment in MCTP courses encouraged teacher candidates to adopt more positive attitudes toward mathematics and science and toward the teaching of these subjects. In addition, the study investigated whether this program fostered certain beliefs about the nature of mathematics and science and how they should be taught. One of the goals of the MCTP program was to promote the development of professional teachers who internalized a constructivist epistemology and who felt confident about teaching mathematics and science. This goal was in accord with the goals promoted by the National Council of Teachers of Mathematics (NCTM, 1989, 1991).

Participants in the McGinnis et al. study (1998) planned to become specialists in upper elementary/middle school mathematics and science teaching. The study began with 535 students enrolled in the MCTP courses during 1995. The following year (1996) the classes were formed into a cohort. Final numbers in the study were considerably diminished due to attrition from the program and lack of response to mail-in surveys.

Attitudes and beliefs were measured by a 37-item Likert scale instrument, *Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science (ABNTMS)* which had been developed especially for the MCTP (McGinnis et al., 1997). This instrument was administered to the same participants at the beginning of the program and several more times over the following two years.

Using a repeated measures t-test analysis design with Bonferonni adjustments, aggregated to the institute level (the mean of the means at the five universities), the researchers (McGinnis et al., 1998) found that the MCTP classes appeared to have affected the teacher candidates' attitudes and beliefs in the direction intended. Two of the subscales of the ABNTMS instrument which measured "beliefs about the nature of mathematics and science" and "beliefs about the teaching of mathematics and science" were statistically significant with a moderate effect size. The "attitudes toward mathematics and science" did not reach a statistically significant change level, however it did show movement in a positive direction, with a moderate effect size. The same result was found on the "attitudes toward teaching mathematics and science" subscale. This study focused on changes in epistemological beliefs, pedagogical beliefs, and attitudes toward mathematics and science. An earlier study by Vinson (1995) focused on another type of belief: personal and general teaching efficacy.

Bandura (1977, 1986) proposed the construct of expectations at two different levels, self-efficacy and outcome expectations. Efficacy deals with an individual's confidence that they can perform certain behaviors. Outcome expectations refer to an individual's confidence that, once actions are taken, the desired results can be obtained. Smith (1996) related this to the teaching of mathematics and posited that it occurs at two levels, personal and general.

The general level referred to outcome expectation beliefs that teachers in general could impact students' learning in a desirable way. Ashton (1985) emphasized the importance of teacher efficacy in her empirical research which found a significant relationship between teacher efficacy and student achievement. Midgley (1986) also found that a change in teacher efficacy was related to students' self- and task-related mathematics beliefs. This important construct also relates to preservice teachers.

Vinson (1995) conducted a longitudinal study of preservice teachers doing field experience in six public elementary schools. Her study was designed to examine the extent to which their personal teaching efficacy and personal and general outcome expectation beliefs changed during field experience. The researcher looked at 58 participants who were completing field experience in four subject areas: language arts, mathematics, science, and social studies. According to the researcher these subjects comprise the core of the elementary curriculum.

Participants in the Vinson study (1996) were administered the same instrument before beginning their field experience and again after completion. The 23-item Likert type questionnaire was a modified version of the Science Teaching Efficacy Belief Instrument (STEBI). The original version was designed for practicing teachers, so the revision reflected future tense verbs to accommodate future teachers. Both multivariate (MANOVA) and univariate analysis of variance (ANOVA) techniques were used to examine the participants' gain scores. The Wilkes-Lambda test did show a significant overall effect among the four subjects and six schools. Follow up univariate ANOVA tests revealed that there was no school-subject effect with respect to general teaching efficacy. Of note here was that mathematics change scores were the lowest of the four subjects. However, personal teaching efficacy did show a statistically significant change score.

Tukey's HSD post hoc tests indicated that personal efficacy in teaching was found to be significantly higher among the preservice teachers in both science and social studies. However, no such change was found in mathematics or language arts. Interviews with students alluded to personal attitudes related to previous experiences in mathematics and beliefs about success in mathematics as an inborn entity were possible confounding factors. Those interviews were conducted for a different purpose, so this was not probed further. Of note from these interviews was a trend for preservice teachers, prior to their field experience, to identify present or previous university instructors as having had an impact on both their personal sense of teaching efficacy and their general teaching efficacy beliefs. After completion, their field experience was identified as a more important influence on teaching efficacy. This was due to the view of field experience as an authentic part of trying out ideas and strategies.

So it appears from the three studies above, teacher preparation programs can have a positive impact on attitudes, efficacy, epistemological and pedagogical beliefs in preservice teachers with respect to some subject area domains. However, recall that both the McDevitt et al. (1993) study and the McGinnis et al. (1998) study looked at cohort type programs. These programs were specifically designed to enhance students' appreciation and attitudes. The Vinson study did not examine such a specialized population, nor did it examine a wide range of beliefs. Only efficacy was examined and the results revealed a positive change in efficacy in science, but not in math. Research related to more typical teacher training programs (non-cohort) or specifically to mathematics, not in combination with other subjects is much scantier and more fragmented and often shows less optimistic results.

Several studies have examined preservice teachers in either a single cross-sectional look or over the course of a single semester. One such study was conducted by Foss & Kleinsasser (1996). They found that preservice teachers' attitudes and beliefs changed little over the course of a semester. During the semester observed by Foss and her colleague (1996), the students were enrolled in a mathematics methods course, in which the teacher stressed the strategies advocated by the reform literature (NCTM, 1989, 1991) and constructivist advocates (Cobb, Yackel, & Wood, 1992). She attempted to model conceptual learning and appropriate teaching styles. This seemed to have little impact on changing preservice teachers' beliefs about effective teaching strategies and their ultimate lesson design. These students tended to design lessons in the manner in which they had originally learned math.

There could be a logical explanation for the results found in the Foss and Kleinsasser (1996) study. These preservice teachers had many years of practice at being students taught by information transmission methods, whereas, this methods class may have been their only exposure to conceptual, reform based teaching. Smith (1996) pointed out that even practicing teachers may fall back on "teaching by telling" and teaching the way they were taught when efficacy is low. Low efficacy and lack of experience may well have been the case with the Foss and Kleinsasser students.

McDevitt and her colleagues (1993) argued that well-prepared and confident teachers are capable of presenting conceptual, hands-on material while teachers with weak preparation tend to rely on the transmitting of information through lecture format. They tend to stress students' memorization and teach as they were taught. Borko, Eisenhart, Brown, Underhill, Jones, & Agard (1992) found evidence to validate that argument. The researchers observed that student teachers tend to fall back on drill and practice (memorization) when they lack the depth of knowledge required to explain something conceptually even when they state the belief in conceptual learning.

Other studies have also noted this same lack of success in changing preservice elementary mathematics teachers' attitudes and beliefs (Ball, 1990; McDiarmid, 1990). But in each case these studies only examined a small sample of students and looked at them only during a single semester or shorter block course.

In summary, researchers have found mixed results when examining preservice teachers' attitudes and beliefs about effective teaching and their ability to implement it. In some studies, positive results appear to emerge as a result of the teacher preparation program. Recall that both the McDevitt et al. (1993) and the McGinnis et al. (1998) studies showed changes in a positive direction with respect to attitudes toward teaching and learning to teach mathematics and science. Both studies examined longitudinal cohort programs which had as a goal the enhancement of positive attitudes. Additionally, in both studies participants were highly motivated to teach mathematics and science when entering the study.

On the other hand, the Vinson (1995) study looked at noncohort preservice teachers before and after student teaching. That study found an overall significant change toward higher efficacy beliefs when four subject areas were examined simultaneously. However, this was not true for efficacy beliefs about mathematics. Other studies which also showed a lack of change in attitudes toward mathematics or in beliefs about teaching and learning mathematics (Ball, 1990; Foss & Kleinsasser, 1996; McDiarmid, 1990) all involved small samples, short time-frames, or only single observations. It is difficult to generalize from these limited studies.

No studies looked at attitudes, efficacy, outcome expectations, pedagogical beliefs and epistemological views on the nature of mathematics as a system of beliefs of preservice teachers. Likewise, no studies looked at student changes in beliefs over several semesters except those which had attitudinal changes as a specific goal of the program. In addition, these were all cohort type programs. The focus of the current study was to look at all of these constructs in the context of a progressive teacher education program at several different points in the students' educational development. This program had, as an overarching goal, the promotion of reflective critical thinking in preservice teachers about their beliefs on effective teaching.

In each of the research studies reviewed above, the importance of teacher preparation programs on preservice teachers' attitudes and beliefs is examined. The NCTM standards (1989, 1991) emphasize that children need teachers who are motivated, model positive attitudes, and are confident of their own teaching skills. Many teacher preparation programs have this as a prominent goal.

The examination as to whether teacher preparation programs address these goals has been encouraged by many theorists (Ernest,1989; Pajares, 1992, 1996; Smith, 1995). Ernest (1989) argued that attitudes, beliefs, and knowledge are three equally important components in shaping teachers' actions in the classroom and should all be considered in teacher preparation programs. McDevitt and her colleagues (1993) also cited evidence that teacher attitudes toward mathematics are a critical influence on their instruction. They stated that teachers' beliefs affect the amount of time spent in teaching the subject and methods that are used in the classroom. For this reason, they argued that beliefs and attitudes should be a part of the teacher training program.

In the elementary teacher education program which was the focus of this study, the importance of prospective teachers' beliefs has been acknowledged. The design of its elementary education program is based on a basic belief that preservice teachers should develop an ability to examine personal and pedagogical beliefs.

The teacher education program in this study focuses on students' understanding of all types of pedagogical views, including a constructivist orientation. Researchers disagree on the exact definition of Constructivism. However, with respect to mathematics, the NCTM (1989, 1991) standards offer guidelines for teaching from this epistemological viewpoint. Teaching should be student centered and address conceptual understanding, logical reasoning, and fundamental understanding rather than rote memorization. Connections are made across the elements of the discipline. Lecture is minimized and student based problem solving which incorporates interdisciplinary connections is emphasized. Students are encouraged to reflect on their own mathematical thinking (Cobb, 1992). Ernest referred to this view of teaching and learning as "problem-driven" and Raymond (1997) referred to this as "non-traditional". Raymond has summarized the view of teachers and students within this epistemological framework in table format (see Appendix C).

A need has existed to examine preservice teachers' attitudes toward mathematics and beliefs about what is effective mathematics instruction and their ability to implement it. While all of the studies cited above have some elements of this, no cohesive body of research exists which addresses attitudes, efficacy, epistemology and pedagogical beliefs in preservice elementary teachers preparing to teach mathematics. How these constructs tie together into preservice teachers' belief systems and how they differ based on the amount of educational experience is another focus of the current study.

In order to effectively study a complex construct like belief systems, Pajares (1992) pointed out the importance of careful design and operationalization of the variables. The constructs described above have been incorporated into the current study as the dependent variables.

Dependent variables for the current study include: (a) personal attitudes toward mathematics and learning to teach mathematics, (b) epistemological beliefs about the nature and learning of mathematics, (c) pedagogical beliefs about what is effective teaching in mathematics, (d) self-efficacy beliefs for learning to teach mathematics and their ability to implement what has been learned, (e) outcome expectation beliefs about teachers' ability to effect students' learning of mathematics, (f) expectations for effort in teaching mathematics, and (g) expectations that the teacher education program will be effective.

Variable 1:
Attitudes toward Mathematics and
Learning to Teach Mathematics

Like beliefs in general, the affective component of cognition, which I have labeled "attitudes", is a complex and multidimensional construct. In a Meta-analysis of 113 primary studies relating this construct of attitudes toward mathematics (ATM) to achievement in mathematics (AIM), Ma and Kishor (1997) found that many researchers believe there is an important connection between the cognitive and affective domains in learning. In fact, incorporation of both these domains is encouraged by the reform literature (NCTM, 1989, 1991).

Ma and Kishor found that attitude was referred to in a variety of ways in the literature. For example one researcher referred to attitude as a learned predisposition to respond positively or negatively to some concept, object, situation, or other person. Another researcher added that this positive or negative response is relatively stable and usually moderate in intensity. Others referred to the "liking" or "disliking" component in ATM. For their meta-analysis, Ma and Kishor also examined studies which included these descriptors of ATM: avoidance of mathematical activity, belief in personal ability in mathematics, usefulness of mathematics, difficulty of mathematics, and importance/unimportance view of mathematics.

Through a common effect size correlation coefficient, Ma and Kishor (1997) found that the ATM/AIM relationship is dependent on a number of variables including sample size, method of data collection, background of participants and other confounding variables. They also found mixed conclusions from researchers. Many argued that there existed a strong relationship between ATM and AIM. Other researchers found the relationship low or nonexistent. Thus, the meta-analysis yielded the not too surprising result of a low relationship. The authors had several recommendations involving future research in attitudes toward mathematics. Among their recommendations was careful research design and use of valid instruments.

In the Ma and Kishor (1997) meta-analysis, gender was not found to have a significant effect on mathematics achievement nor was gender found to interact with other variables such as ethnicity when examining AIM. However, other researchers have argued that gender does play a role in influencing attitude and achievement.

Attitudes to both mathematics and science were examined in a narrative review of the literature done by Garaway in 1994. How students relate to the system, or their attitudes, was found by Garaway's synthesis of the literature to be a primary barrier in achievement for minorities and females when it is negative. He stated that:

> Given an abundance of approaches, techniques, and [teaching] strategies, there is still the bottom line-interest and motivation...While a skillful technique, or meaningful activity may momentarily capture the attention of students, the foundational issue of how the students relate to the system as a whole must be dealt with. (p. 105)

Other researchers have also argued that gender is an important factor when considering attitudes toward mathematics.

Because most of the students planning to enter the elementary education profession are female, Becker (1986) felt that gender was an important issue to be considered in her study. As an elementary mathematics methods instructor, she conducted research to determine the extent to which her students seemed to have the negative attitudes and mathematical anxiety so often referred to in research on females.

In the Becker (1986) study, eighty-one elementary education majors enrolled in a required mathematics course were compared to seventy-one students enrolled in an astronomy course. Students were measured on seven subscales of a valid and reliable instrument (Fennema & Sherman, 1976). These subscales will be discussed in more detail later in this section. Responses were collapsed across subscales and averages were compared. On two of the subscales, attitudes toward success in mathematics and the usefulness of mathematics, she found that the elementary teachers were rather positive in attitude. The education students were significantly lower (more anxious) than the astronomy students on the mathematics anxiety scale and their averages on this scale were lower than on any other. However, on an item by item analysis of means, Becker felt that there was some reason for optimism. She felt that, for this sample, the students were not "highly anxious" and in most ways their attitudes were comparable to the general sample.

The instrument used in the Becker (1986) study was a revised version of the *Fennema-Sherman Mathematics Attitude Scale* (Fennema and Sherman, 1976). The Fennema and Sherman instrument was designed to incorporate gender, as well as other components of self and social influences within the context of mathematics. The purpose was to examine attitudes in mathematics. The instrument, *Fennema-Sherman Mathematics Attitudes Scales* is still used extensively today. Fennema and Sherman posited that there are nine subscales of attitude that could be measured independently. These are: *Attitude toward Success in Mathematics*, *Mathematics as a Male Domain*, *Mother Scale*, *Father Scale*, *Teacher Scale*, *Confidence in Learning Mathematics*, *Mathematics Anxiety*, *Effectance Motivation*, and *Mathematics Usefulness*. The researchers acknowledged that these subscale domains do intersect and the observant reader will recognize several of these scales are also elements of underlying principles within other constructs. In addition, certain researchers have claimed that some of these subscales are composed of distinct factors (Pajares, 1986).

Consider, for example, the *Effectance of Mathematics* and the *Mathematics Usefulness* scales. According to the researchers, the effectance scale ranges from "lack of involvement in mathematics to active enjoyment and seeking of challenge" (Fennema & Sherman, 1997, p. 325). The usefulness scale is designed to measure the current usefulness of mathematics to the individual as well as its future utility in education, vocation, or other areas. Goal theorists would argue that these scales are in reality measuring a students' learning, performance, or future utility goals (e.g., Dweck, 1986; Schunk, 1983, 1989; Weiner, 1984).

Csikszentmihaly & Nakamura (1989) would argue that effectance is actually measuring intrinsic motivation. And other researchers would argue that even the nine subscales mentioned by Fennema and Sherman (1976) may have multiple factors (Pajares, 1986).

However, despite its critics, this scale is well thought of and is still widely used. For example, attitudes of preservice mathematics and science students in the McDevitt et al. (1993) study were measured using six subscales from the Fennema-Sherman (1976) instrument.

McDevitt et al. (1993), as well as other researchers, have argued the importance of fostering positive attitudes in teacher preparation programs (Ball, 1990; Ernest, 1989; McDiarmid, 1990; McGinnis et al., 1997; McGinnis et al., 1998). They cite not only the impact attitudes have on the choices these students make in their career training, but also the role that attitudes play in teachers' behaviors in the classroom. In addition, the NCTM (1989) encourages mathematics educators to incorporate affective factors with cognitive factors in mathematics teaching and learning (Ma et al., 1994). Researchers have verified that positive attitudes and strong motivation have been positively correlated to students' attitudes and play a part in fostering students' enjoyment in learning (Carpenter, Fennema, & Franke, 1997).

Because the first step in becoming a successful teacher of mathematics is developing a solid background in the subject, this study will examine the attitudes of preservice teachers toward learning mathematics, as well as their attitudes toward learning to teach it. However confounding variables such as goals, social variables, and gender issues are not examined in this study. While important, these issues are left to another study. Confidence in ability to learn and to teach mathematics is examined as a separate construct which will be discussed later in the section on efficacy.

In addition to preservice teachers' personal attitudes toward mathematics, another belief which has caught the attention of researchers deals with how learners approach learning. For example, Schommer (1990, 1994) theorized that individuals' beliefs about the nature of knowledge and learning may influence how they approach learning. She called these *Epistemological* beliefs, and these are the next construct of interest to this study.

Variable 2: Epistemological Beliefs

Schommer (1990, 1994) theorized that individuals' beliefs about what knowledge is and how it is acquired may influence how learning is approached. According to Schommer this complex set of beliefs about the nature of knowledge and learning make up what she calls an individuals' epistemological belief system. She proposed a system of five more or less independent epistemological *dimensions*. These dimensions include: Certainty of knowledge, Structure of knowledge, Source of knowledge, Control of knowledge, and Speed of knowledge acquisition.

The first of Schommer's (1990, 1994) dimensions involves the nature of knowledge. Certainty of knowledge, according to that theorist deals with the degree to which an individual believes knowledge is absolute. The continuum varies from the belief that all knowledge is absolute to the belief that all knowledge is tentative. Structure of knowledge is the perception of the organization of knowledge. Some may perceive knowledge as a highly organized set of interacting concepts while others perceive knowledge as composed of isolated, unrelated facts. In addition to beliefs about the nature of knowledge (its absoluteness and organization) Schommer posited that another dimension of epistemological beliefs is related to how knowledge is acquired.

Knowledge acquisition involves Source, Control, and Speed. When considering the Source of knowledge, Schommer (1990, 1994) suggested that some learners believe knowledge is handed down from authority figures. Others believe that knowledge is created through human reasoning. Schommer's definition of control of knowledge has its roots in theories such as those proposed by Weiner (1984), Schunk (1983, 1989), and Dweck (1986). These theorists suggested that a framework for learning is established through a learner's beliefs about ability, attributional feedback, and mastery oriented goals. Thus Schommer's definition of Control of knowledge deals with the degree to which an individual believes that the ability to learn is fixed from birth or incremental and can be changed. In other words, some individuals believe they simply do not have the ability to learn certain material, while others believe that any knowledge can be mastered through effort and persistence.

The final epistemological dimension defined by Schommer (1990, 1994) deals with the speed of knowledge acquisition. Again, we can see the relationship to the research of Dweck (1986) and mastery versus performance goal orientation. Schommer proposed that some individuals believe that if knowledge is to be mastered at all, it must be acquired quickly. On the other hand, others believe that knowledge acquisition is gradual and steady, requiring effort and persistence.

Schommer (1990, 1994) tentatively suggested that many hold naive or unsophisticated belief systems. A person who holds a naive belief system, may believe that knowledge is certain, is supplied by authorities, and must be learned quickly if it is to be learned at all. In addition, this naive learner believes that an individual must have an innate ability to master material and, because knowledge is fixed and unrelated, he/she believes that rote memorization is the best way to acquire knowledge. On the other hand, a person who holds a more sophisticated epistemological belief system believes that much knowledge is tentative and much effort and persistence is required for the ultimate mastery of complex material. The philosophy or belief system a student holds guides them in the way they approach the acquisition of knowledge.

Schommer (1990, 1994) supplied empirical evidence for her theory of epistemological beliefs. She found that systems of the five dimensions mentioned above were related to learning. For example, a strong belief in simple, isolated knowledge has been found to predict text comprehension. Those who held this epistemological belief seemed to read educational material for declarative level knowledge without searching for underlying meanings and connections.

In support of her control dimension, Schommer (1990, 1994) cited the work of Dweck (1986). Dweck's research supplied evidence for the relationship between children's persistence levels and their beliefs in fixed ability to acquire knowledge.

Mathematics researchers have also recognized the importance of epistemological believes in their domain. The National Council of Teachers of Mathematics in its publications Curriculum and Evaluation Standards for School Mathematics (1989) and Professional Standards for Teaching Mathematics (1991) encouraged a progressive epistemological view of mathematics. However, just as Schommer (1990, 1994) suggested, those who teach and study mathematics can also hold an assortment of epistemological views about the nature of mathematics knowledge and learning.

Ernest (1989) suggested there are three main epistemological or philosophical views about the nature of mathematics. In the past, many educators viewed mathematics learning as the memorization of a series of rules and procedures. Mathematics was viewed as a "useful but unrelated collection of facts, rules, and skills". He called this viewpoint the instrumentalist view. The role of students was to drill and practice until they mastered the more or less isolated and unrelated algorithms. Raymond (1997) refers to this as the traditional view. An adaptation of Raymond's summary of the key aspects of this epistemological view, as well as others, can be found in Table 3 (see Appendix C).

A second epistemological view of mathematics was labeled by Ernest (1989) as the Platonist view. In this viewpoint, mathematics is a static but unified body of knowledge consisting of interconnecting structure and absolute truths. Mathematics knowledge is not created but its monolithic truths are discovered.

However, the more progressive view of the nature of mathematics encouraged by the NCTM (1989, 1991) is that of mathematics as a dynamic, problem-driven branch of science, which is a "continually expanding field of human inquiry", in which learners actively construct new knowledge. Ernest (1989) refers to this epistemological view of mathematics as the "problem-solving view". Raymond (1997) refers to this as the "nontraditional" view of mathematics (see also Table 3, Appendix C). Students are visualized by educators who hold this epistemological view as mathematical thinkers who understand concepts, use reasoning, solve problems in new and diverse contexts, and who have developed a sense of their own mathematical power (Smith, 1996). It is this latter epistemological view that is advocated by the NCTM Curriculum Standards (1989). Raymond's (1997) summary of these philosophical views of learners also appears in Appendix C.

Raymond (1997) posited that the epistemological views an educator holds about the nature of mathematics knowledge and learning impacts his/her approach to teaching. The tables presented in Appendix C summarize how Raymond perceived the relationship between epistemological views on the nature of mathematics and related views on learning and teaching techniques. Because many researchers do suggest a relationship between epistemological belief systems and pedagogical beliefs the next variable to be considered is that of pedagogical beliefs.

Variable 3:
Pedagogical Beliefs

Because of the theoretical relationship between epistemological views and choices of teaching styles, the next variable to be examined deals with preservice teachers' beliefs about how mathematics should be taught. These pedagogical beliefs represent another variable of great concern since teaching styles may be important to children's learning.

For today's researchers in mathematics education, how students learn is of primary concern. According to the NCTM standards (NCTM, 1989, 1991), what a student learns depends on how it is learned. Learning through inquiry, investigation, and self-construction of knowledge is now a major emphasis in the mathematics curriculum. Many theorists believe this type of learning leads to the best understanding of new information as the child constructs his/her knowledge by building on existing schemas (Carpenter, Fennema, & Franke, 1996; Cobb, Yackel, & Wood, 1992; DeVries, 1997). The students' learning is influenced by the teacher's mode of teaching. That mode of presenting material can be influenced by the teachers' beliefs about how mathematics is learned and should be taught. Such views can be termed as the teachers' pedagogical views. Raymond (1997) posited that a teacher's pedagogical views were strongly tied to his/her epistemological views. She synthesized the theoretical work of Ernest (1989) into her own views of how student learning, the mode of teaching, and the epistemological views of the teacher are interrelated. These views are presented in table form in Appendix C.

Briefly, Raymond (1997) posited that the traditionalists view mathematics as an unrelated collection of facts, rules, and skills. They think of mathematics as fixed, predictable, absolute, certain, and applicable. Thus, teachers who hold this viewpoint, believe that the instructor's role is to lecture, demonstrate, and to dispense mathematical knowledge. In addition, they believe the teacher's role is to seek "right answers" and to assign individual seatwork in order to accomplish this outcome. Mastery and memorization of skills and facts is emphasized. The teacher assesses students solely through standard quizzes and exams.

According to Raymond (1997), teachers who hold the traditional view of teaching also view the students differently. Students are viewed as passively receiving knowledge from the teacher. They learn by repeated practice for mastery of skills, which is best done by working individually. Usually these teachers work solely from the textbook and worksheets. Such teachers also often view learning of mathematics as depending on an innate ability and they expect that many students are just not able to learn mathematics.

On the other hand, Raymond (1997) theorized very different views in what she termed the nontraditional teacher. The epistemological view held by these teachers is that mathematics is a dynamic, problem driven, and continually expanding science, which can be surprising, relative, doubtful, and aesthetic. Because of this viewpoint, these teachers believe material should be presented differently. They believe the teacher's role is to guide learning and pose challenging questions.

According to Raymond (1997), nontraditional teachers value process over product and hence do not follow the textbook when teaching. Rather, these teachers provide only problem-solving, manipulative driven activities. They rarely plan explicit, inflexible lessons. Students work in cooperative groups at all times. As members of the group, students are encouraged to communicate their own strategies and collaborate on solving large problems. In addition, the teacher promotes student's reflection on his/her mathematical thinking. The teacher helps students to like and value mathematics by selecting tasks based on students' interests and experiences.

The students' role is viewed differently in the nontraditional classroom also according to Raymond (1997). Students are viewed as active participants in the learning process who are encouraged to be autonomous explorers of mathematics. All students are viewed as capable of learning mathematics, contrary to the traditional view where only students with special talents are expected to really master complex mathematical ideas. In the nontraditional view, teachers recognize that each individual constructs knowledge in a unique way, thus each student learns mathematics slightly differently. This nontraditional view of learners actively constructing knowledge through hands-on experience and interpreting their experience based on prior knowledge is often called a constructivist orientation (McGinnis et al., 1997).

Because the constructivist orientation has been found to be a highly effective strategy to maximize students' conceptual understanding of mathematics (Franke & Carey, 1997; Fuson, Wearne, Hiebert, Murray, Human, & Oliver, 1997; Hiebert & Wearne, 1992; Matsushita, 1994; Mulligan, & Michael, 1997; Perry, VanderStoep, & Yu, 1991) researchers have sought to study the extent to which these beliefs have been incorporated by preservice teachers. One such study, Fleener and Nicholas (1994) used isolation analysis to determine preservice teachers' beliefs about the teaching and learning of mathematics.

The Fleener and Nicholas study (1994) investigated teacher candidates' beliefs before and after completion of the coursework in an elementary mathematics methods class. One hundred twenty-seven students from eight methods classes participated in the study. The classes were designed to promote the understanding of social constructivist orientation as well as other orientations toward teaching mathematics in grades four through eight. The researchers posited that many of the students would have learned mathematics in a more traditional manner and thus would experience conflicts between beliefs developed through experiences as a student and pedagogical theories presented in the classroom.

To examine the changes in beliefs that occurred as a result of the coursework, a researcher constructed instrument, *Teacher Belief and Attitude Survey in Mathematics* (T-BASM), was administered at the beginning and end of the semester. In addition, student journals and classroom observations were incorporated into the obtained data. The three constructs assessed were beliefs about mathematics learning, mathematics teaching, and classroom control. Isolation analysis identified the parameters of the belief clusters of the participants. Four groups of students were identified: (a) students who held traditional beliefs both before and after coursework, (b) students who held constructivists orientation both before and after coursework, (c) students who held a mixture of constructivist and traditionalist beliefs both before and after coursework, and (d) students who moved from a traditionalist view to a constructivist orientation. Shifts in beliefs were in the constructivist direction, although a majority of the participants did not have large difference scores or dramatic change scores on the two administrations of the T-BASM.

The researchers (Fleener & Nicholas, 1994) concluded that their preservice teachers may hold contradictory and independent belief clusters about the teaching and learning of mathematics. These beliefs seem to be of varying strengths and hold the potential to be mapped into new knowledge and experiences. The researchers posited that such belief clusters may help individuals cope with such ill-structured problems as teaching. Thus, this adaptability of belief systems may account for the reluctance of participants to change core beliefs.

Preservice teachers' beliefs about pedagogy has been selected as a critical variable for this study. The purpose of this study is to examine beliefs held by preservice teachers about what is effective teaching and their ability to implement it. Even if prospective teachers understand and appreciate a constructivist orientation to pedagogy they are unlikely to implement appropriate practices if they don't have confidence in their own abilities to implement these strategies. On the other hand, even if they believe they are capable of implementation, preservice teachers may still believe that these strategies may not work in real life. They may believe that no one can succeed with certain students (Vinson, 1995). Thus efficacy and outcome expectation beliefs are the variables to be considered next.

Variables 4 and 5:
Efficacy and Outcome Beliefs

Perspectives on how mathematics should be taught can only take shape if a preservice teacher believes he/she is capable of presenting material effectively. When Maehr (1984) presented his theory on motivation, which he called "Personal Investment", he posited that a person's "sense of self" is an integral part of motivation. He defined the sense of self as the "more-or-less-organized collections of perceptions, beliefs, and feelings related to who one is", including "judgments about one's competence" (p. 126). He further explained that this sense of self acts as a filter through which information is perceived and interpreted thus giving meaning to a situation.

Maehr's (1984) self judgment of competence was the psychological construct which Bandura (1977) called "self-efficacy". Both Bandura's and Maehr's theories emphasized that this belief about oneself is dynamic and situation specific.

Several researchers have tied self-efficacy to the educational setting (Ashton, 1985; Midgley, Feldaufer, & Eccles, 1989; Pajares, 1996; Smith, 1996). These researchers found evidence to support the notion that a teacher is bound to make judgments about his/her competence in the classroom. Thus, a basic belief of teachers relates to teaching efficacy.

Ashton (1985) defined teachers' sense of efficacy as the "belief in their ability to have positive effect on students' learning" (p. 142). She conceptualized beliefs about teaching efficacy as having two hierarchical dimensions or categories.

Ashton (1985) described the first dimension of teaching efficacy as teachers' outcome expectations. This dimension refers to teachers as a group and thus is referred to, in other literature (Pajares, 1996, Smith, 1996, Vinson, 1995), as a "general" teaching efficacy. This belief about general teaching efficacy alludes to the ability of teachers, as a group, to produce student learning in spite of obstacles. An efficacious teacher believes that there are teachers who can positively effect students' learning in spite of problematic student variables and community pressures. Note that this level would probably have been referred to by Bandura (1977, 1986) as outcome expectancy beliefs. Bandura argued that self-efficacy deals with one's confidence in his/her ability to effectively implement certain behaviors. This belief may affect whether a person chooses to take a certain course of action. Outcome expectations, on the other hand, occur at a different level. Here, a person may believe he/she is perfectly capable of performing certain activities, but not believe the activity will produce the desired outcome. Here, again, this belief may affect whether a person chooses to engage in certain behaviors, but for different reasons. In Bandura's definition, Ashton's first dimension thus would be more properly defined as general teaching outcome expectations. In teachers, outcome expectation beliefs may be related to personal or general levels.

The second dimension Ashton (1985) referred to is a teacher's personal sense of efficacy. According to Ashton, this is the belief that a teacher holds about his/her own ability or competence in a given teaching situation. Bandura (1977, 1986) would point out this is the belief in an individual's proficiency to perform given activities. Teachers with a high sense of efficacy believe they can implement effective teaching strategies. Teachers with positive outcome expectation beliefs attribute their own actions as causal agents in students' learning in their classrooms.

Bandura (1977, 1986) focused on self efficacy as it relates to persistence and effort. If teachers believe they can be effective in the classroom, they will be more persistent in pursuing creative lesson plans, working with troubled students, and generally putting forth effort to do a good job (Pajares, 1996; Smith, 1996). The greater the teacher's efficacy, the more effort and persistence is utilized in accomplishing a difficult task.

Therefore, the two final variables that were examined in this study included, first, the preservice teachers' beliefs about their personal efficacy in implementing effective mathematics teaching strategies. The second dealt with their outcome expectation beliefs on both a personal and general teaching level.

Summary

Researchers have argued that attitudes and beliefs play a significant role in the actions we take in any given situation. Most teacher education programs have, in one form or another, goals that are related to student beliefs regarding teaching and learning. Some programs explicitly attempt to influence their students' beliefs about the most appropriate methods of teaching and the most appropriate models of student learning. Others explicitly attempt to strengthen their students' self-related beliefs (self-efficacy) regarding teaching. Still others attempt to foster critical thinking and reflective practice among their students. In all these cases, the effectiveness of the teacher education curriculum in reaching these goals will be mediated by the student's initial belief systems and the beliefs they develop throughout their programs of study. For this reason, it is important to gain a greater understanding of the beliefs of prospective teachers at various points in their development as teachers.

With this in mind, five variables were reviewed above as important beliefs that preservice teachers hold. These include:

1. the preservice teachers' personal attitudes toward mathematics,
2. their epistemological beliefs about the nature of mathematics and how it is learned,
3. their pedagogical views about what is effective mathematics teaching,
4. personal efficacy about their ability to implement effective teaching strategies, and
5. outcome expectation beliefs about the effectiveness of teaching strategies on both a personal and general level.

These beliefs were examined in the context of one teacher education program and one subject area within the elementary education curriculum in that program. The intent of the current study was to examine these attitudes and beliefs at several points in their educational experience. A comparison of these beliefs among the different levels revealed some insights as to the trends in belief systems. An understanding of the dynamics of belief systems may be one more factor contributing to the development of prospective teachers who approach the teaching of mathematics with positive attitudes and who can reflect critically on their beliefs about what is effective teaching and their ability to implement it.

CHAPTER III

METHODOLOGY

The purpose of the current study was to determine what beliefs preservice teachers hold about what is effective mathematics teaching and their ability to become effective mathematics teachers. In addition, the study examined the trends in systems of beliefs held by different populations of preservice elementary teachers and whether these trends differed significantly by experience in the program. Specifically, the following research questions were examined:

1. What are the beliefs about mathematics held by preservice elementary and early childhood teachers before, during, and after completion of teacher preparation coursework?
2. What are the relationships among the attitudes and personal, pedagogical,and epistemological beliefs at each of four levels of the teacher preparation program?
3. Do the patterns of relationships among the attitudes and personal, pedagogical, and epistemological beliefs of students at the four levels of the teacher preparation program differ?

Pajaras (1992) emphasized that, when exploring a complex construct like teachers' belief systems, careful consideration should be given to the research design and operationalization of the variables. In order to facilitate this process, great care was taken in instrument development. This included conducting a pilot study, a complete summary of which can be found in Appendix D. The following sections will address the design of the current study, the instrument development, the population involved in the study, and the data analysis methods used to complete the study.

Design

The study was quasi-experimental, containing elements of descriptive, causal comparative, and correlational designs. The descriptive method was used to address research question one above. This involved describing characteristics of a sample of individuals (Gall, Borg, & Gall, 1996). Research question two was addressed using a correlational method. This method was used to study the relationships between variables. Question three was addressed by using the causal-comparative method. In this method, comparisons among variables are explored.

Through previous research examined in the literature review section of this document and through a preliminary pilot study (see Appendix D), several dependent variables were proposed as appropriate for this study. These include: (a) personal attitudes toward mathematics, (b) personal attitudes about learning to teach mathematics,

(c) epistemological beliefs about the nature and learning of mathematics, (d) pedagogical beliefs about what is effective teaching in mathematics, (e) self-efficacy beliefs about learning to teach mathematics, (f) self-efficacy beliefs about personal ability to implement what has been learned, (g)beliefs about the effectiveness of the teacher preparation program, and (h) outcome expectation beliefs about the ability to effect students' learning of mathematics, both on a personal and general teaching level. A discussion of the instrument used to measure those variables and its development follows.

Instrument

Instrument development.

To examine the attitudes and belief systems held by preservice teachers, a structured questionnaire was developed. Several existing instruments that have good reliability and validity evidence exist which examine some of the constructs related to teacher beliefs. Those constructs include attitudes toward mathematics, epistemological beliefs about the nature and learning of mathematics, pedagogical beliefs about what is effective mathematics teaching, self-efficacy beliefs about their ability to implement effective teaching strategies, and outcome expectation beliefs at both the personal and general level. However, none of the existing instruments measured all of these constructs with respect to preservice teachers' beliefs within the domain of mathematics. Thus, no one instrument was entirely suitable for this study. Therefore, it was necessary to create an instrument which measured the constructs of interest in the domain of mathematics.

Two instruments were available which addressed these constructs and needed only moderate revision and adaptation. The first instrument, *Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science* (ABNTMS) provided an instrument with good reliability and validity evidence for the constructs related to attitude, pedagogical beliefs, and epistemological beliefs (McGinnis, Watanabe, Shama, & Graeber, 1997). The second instrument was created and validated by Curda (1997). This instrument provided valid and reliable items for measuring the efficacy and outcome expectation belief constructs. Other instruments were also examined and items were compared to the two primary instruments (Fennema & Sherman, 1976; Vinson, 1995).

The ABNTMS instrument (McGinnis et al. 1997, 1998) was created for the Maryland Collaboration for Teacher Preparation (MCTP). Development and validation of this instrument was discussed in the literature review section (Chapter Two) of this document. The ABNTMS was designed to measure beliefs about the nature of and attitudes toward both mathematics and science held by teachers seeking certification in those areas. Instrument items from this document required only minor modifications to adapt them to preservice teachers and attitudes toward mathematics, pedagogical beliefs, and epistemological views about the nature and learning of mathematics. The ABNTMS did not measure efficacy or outcome expectation beliefs.

To measure the constructs of self efficacy and outcome expectations, items from the Curda (1997) instrument were examined. That document is based on the theoretical work of Bandura (1977, 1986) and measures teacher efficacy in the domains of reading and mathematics. Permission was obtained from that author to adapt items to be used in the current study. Again little revision was necessary to adjust wording for preservice teachers in the domain of mathematics. Both the McGinnis et al. (1997) and Curda instruments contained Likert-type questions with a 5-point scale from strongly agree to strongly disagree.

Originally 100 items were chosen from the two instruments. These items were clustered into five a priori subscales to match the five constructs being measured. These items are set up on a Likert-type scale, in which the respondent selects from one of the following choices: 1 (strongly disagree), 2 (disagree), 3 (undecided), 4 (agree), or 5 (strongly agree). Within each of the subscales, parallel forms of some items exist so that one is positively worded and the other negatively worded. Thus, after coding in responses as they appeared on the instrument, certain responses would require recoding into appropriate numerical weighting (reverse-scored). Hence, the higher means reflected more positive attitudes, higher self-efficacy, more sophisticated epistemology (Schommer, 1994), and more constructivist pedagogical beliefs. Lower means reflect more negative attitudes, lower self-efficacy, a more naive learning epistemology (Schommer, 1994), and a more traditional (Raymond, 1997) mathematics pedagogy.

The 100 original items were then examined by a panel of twelve university instructors and graduate students. This panel examined both the items and instructions for clarity of wording. Following this review of the instrument, two experts in the field (Educational Psychology professors) examined each item to determine its "fit" with the construct it was intended to measure. Based on the feedback from these two reviewing processes, the final 83-item instrument was developed. The complete instrument, along with a 12-item student information sheet can be found in Appendix B.

To insure the confidentiality and safety of the participants, the instrument and procedures were then reviewed by the University Institutional Review Board (IRB). The documents required by the IRB (consent forms) can be found in Appendix A.

After data collection, the instrument was further refined. This was accomplished through a second-order factor analysis. In a second-order factor analysis, an internal reliability over the whole instrument is first computed. This is followed by factor analysis of the a priori subscales. The rationale for using this procedure comes from the limited sample size. In a first order factor analysis the recommended ratio of participants to items is 15 to 1 (Gall et al., 1996). In the current study, an 83-item instrument was employed. This would have required 1245 participants to conduct an optimal factor analysis. However, the 226 participants were adequate for a second order factor analysis, since no final subscale contained more than 11 items, bringing the ratio well within 15 to 1.

Following the procedure described above, an internal reliability score was computed on the entire instrument using the Cronbach's Alpha statistic (Gall et al., 1996). This was followed by a Principle Component Extraction method of factor analysis on each of the subscales. This second order factor analysis revealed slightly different clusterings of items than the original five a priori subscales. Nine distinct variables emerged from this procedure. A description of the nine new variables follows.

Attitude was the first variable to be examined in the current study. Factor analysis revealed nine items clustered into the same component to measure student attitudes about mathematics (items 1,2,3,4,5,6,7,8,34). Efficacy was divided into two components. Eleven items were intended to measure personal self-efficacy related to confidence in ability (items 12,13,14,15,16,17,19,20,21,22,23). A single item (28) was intended to measure the student's feelings about being prepared to teach mathematics. The items originally intended to measure outcome expectations for the act of teaching clustered into three distinct components. The first, preservice teachers' beliefs about teacher control of student outcomes was measured by three items (30,31,32). The second subscale examined the preservice teacher's expectation toward the effort involved in teaching math (35,36,37). The final subscale measures students' expectations that the teacher preparation program had left them well prepared to teach mathematics (42,43,44). Second order factor analysis also revealed that Pedagogical beliefs clearly clustered into two distinct categories: traditionalist views (items 49, 50,52,53,59,61,63,64,65,70) and constructivist views (items 51,54,57,58,62,67,68,69). For the final variable, eight items concerning Epistemology clustered into one component labeled general epistemology (items 71,72,74,77,78,79,80,81). Those items which did not cluster into the subscales as expected were them examined individually and omitted from the final analysis if they did not appear to contribute further pertinent information. Reliability of the subscale was examined with and without these items. Table 1 lists the description of each of the nine variables and those items intended to measure those constructs. Following the table the procedure for collecting the data used in both the factor analysis and the final research analysis is discussed in the next section.

Table 1 Constructs and All Related Items

Construct: Attitudes toward mathematics

1. I am looking forward to taking more mathematics courses.
2. I enjoy learning how to use technologies (e.g., calculators, computers, etc.) in mathematics classrooms.
3. I like mathematics.
4. I possess the ability to understand and work with mathematics.
5. I find learning math is very stressful.
6. The idea of teaching mathematics scares me.
7. I think I will prefer teaching mathematics to teaching other subjects.
8. I am looking forward to taking more mathematics methods courses.

34. I am looking forward to teaching math.

Table 1 Constructs and All Related Items, continued

Construct: Self-efficacy related to becoming a mathematics teacher

12. I am capable of providing instruction in math based on my students' interests.

13. I am capable of providing math instruction using a variety of hands-on manipulatives.

14. I have the ability to adjust my classroom activities in math to the learning needs of individual students.

15. I am capable of providing appropriate learning experiences in math for diverse learners (e.g., gifted, learning disabled, attention deficit, non-English speaking).

16. I have the ability to integrate math activities into other curriculum areas.

17. I have the ability to provide students with challenging activities in math.

19. I have the ability to plan effective lessons in math.

20. I have the ability to apply cooperative group learning strategies in teaching math.

21. I have the ability to provide worked examples during math instruction.

22. I am capable of conducting whole group instruction in math.

23. I am capable of conducting small group instruction in math.

Construct: Self-efficacy related to being prepared to teach

28. I feel prepared to teach mathematics.

Construct: Outcome expectations, teacher controls of student outcomes

30. I believe that I will be responsible for my students' achievement in math.

31. I think most teachers can positively affect student achievement in math.

Table 1 Constructs and All Related Items, continued

32. I believe teachers have control over their students' achievement in math.

Construct: Expected effort involved in teaching math

35. Compared to other subjects I will teach, I expect to put more effort into working with students who are having trouble grasping a new math concept or procedure than students in other subjects.
36. Compared to other subjects I will teach, I expect to put more effort into developing engaging math activities than other subjects.
37. Compared to the effort I expect to exert in planning for other subject areas, I expect to put more effort into planning daily math instruction.

Construct: Expectations related to teacher preparation program

42. I expect that the college mathematics courses I take will be helpful to me in teaching mathematics.
43. I expect that the college educational psychology courses I take will be helpful to me in teaching mathematics.
44. I expect that the mathematics methods courses I take will be helpful to me in teaching math.

Construct: Pedagogy-traditionalist view

48. The teacher should demonstrate how to solve math problems before students are allowed to try solving problems on their own.
50. An effective teacher demonstrates the right way to do a math problem.
52. Most students have to be shown how to solve math problems the right way.

Table 1 Constructs and All Related Items, continued

53. Students will not understand an arithmetic procedure (i.e., two-column addition) until they have memorized some of the basic number facts.

59. When a student is having difficulty solving an arithmetic problem, the teacher should tell the student how to solve the problem.

61. Frequent pencil and paper practice with arithmetic problems is essential in order for students to learn them.

63. Time should be spent practicing basic computational skills before students spend much time working with manipulatives

64. Students need explicit instructions on how to solve most mathematics problems.

65. Students learn mathematics best from teachers' well designed demonstrations and explanations.

70. Calculators should not be available for students when they are learning the basic skills in mathematics.

Construct: Pedagogy-Constructivist viewpoint

51. Students should have many informal experiences solving word problems before they are expected to memorize formulas and algorithms.

54. Students should be allowed to invent ways to solve arithmetic problems before the teacher demonstrates how to solve them.

57. Allowing students to discuss their thinking helps them to make sense of mathematics.

58. Students can figure out ways to solve many kinds of arithmetic problems without formal instruction.

62. Students' explanations of their solutions to arithmetic problems are good indicators of their mathematics learning.

Table 1 Constructs and All Related Items, continued

67. Students should be given regular opportunities to think about what they have learned in the mathematics classroom.

68. Using technologies (e.g., calculators, computers, etc.) in mathematics lessons will improve students understanding of mathematics.

69. Small group activity should be a regular part of the mathematics classroom.

Construct: Epistemological beliefs about the nature and learning of mathematics as fixed knowledge

71. Mathematics consists of unrelated topics (e.g., algebra, arithmetic, calculus and geometry).

72. Getting the correct answer to a problem in the mathematics classroom is more important than investigating the problem in a mathematical manner.

74. Mathematics is a constantly expanding field.

77. I think I will prefer teaching mathematics by emphasizing connections among disciplines.

78. Mathematics should be presented to students in such a way that they can discover relationships for themselves.

79. Students usually can create ways to solve math problems by themselves.

80. Mathematics techniques can be created as a need for it arises in the course of solving a real life problem.

81. Given appropriate materials, students can create meaningful procedures for computation.

Procedure

Two hundred twenty-six early childhood and elementary education preservice teachers were surveyed during a three semester period from the fall of 1998 to the summer of 1999. Participants completed the survey during a regular class period in approximately 15 minutes. Classes participating in the study included a freshman level mathematics class (Critical Thinking in Mathematics), 8 sections of students enrolled in one of two professional education classes (Child/Adolescent Developmental Psychology or Learning/Cognition/Motivation), and 6 sections of students enrolled in either the second or third mathematics methods course offered at the participating university. In all of the mathematics methods and mathematics courses, the surveys were administered at the end of the semester, after students had completed most of the coursework. Four of the educational psychology courses were administered the survey at the beginning of the course, before completion of any coursework, and four other educational psychology courses were administered the survey at the end of the course, after completion of all coursework.

Prior to administration, permission was obtained from both the course instructor and from individual participants (see Appendix A for copies of the permission letters). Neither the survey instrument nor the attached student information sheet contained any information which could have led to identification of the participants. Participants were advised that all information was analyzed in terms of group trends only and that surveys were kept confidential. In some of the classes, participants received a small number of points for participating in the survey.

Sample

Two hundred twenty-six students enrolled in elementary education or early childhood education at a large suburban university located in the Southwest participated in the study. That university offers a progressive teacher education program. The College of Education is unique among that state's colleges and universities in offering a program called the *Teacher Education - Professionalism, Leadership, Understanding, Scholarship (TE-PLUS)* program. TE-PLUS requires a Bachelor's Degree plus nine graduate hours to become certified in education. While obtaining the Bachelor's Degree, the coursework is concentrated in content and general education areas. During that time an elementary teacher candidate is required to participate in around 200 hours of field experience in addition to the student teaching internship. Beginning at the sophomore year, the developmental field experiences allow the preservice teacher more and more responsibility in working with diverse student populations. The teacher candidates are required to obtain experience in rural, suburban, and urban settings so as to become familiar with diverse cultural, ethnic, and socioeconomic populations of children.

After completion of at least 124 credit hours toward obtaining the Bachelor's Degree, the teacher candidate begins a full 16-week semester of student teaching, for which they obtain graduate credit that can be applied toward a Master's Degree. At all levels, the preservice teacher receives both school and university mentorship.

While obtaining elementary certification in the TE-PLUS program, each participant is required to take 12 or more hours of mathematics content, six professional education courses, and three sequential mathematics methods (content and pedagogy) courses. The six professional education courses include two in educational psychology, as well as classes in technology, cultural diversity, special education and parent and community relations. Participants came from fifteen sections of mathematics, mathematics methods, or professional education classes over a three semester period.

Ninety-seven percent of the participants were female. The group was primarily Caucasian (90%), with the remainder from a variety of ethnic groups including African-Americans, Asian, Native Americans, Hispanic, and Pacific Islanders. For the current study participants were grouped into five categories based on educational background.

The first group (Pre-Ed) included 46 participants who had not yet completed any educational psychology courses. These students also designated that they had completed either one or no elementary mathematics methods courses. Ninety-six percent of these students were female and 48% considered themselves average math students (good, 39%, poor 15%). The majority of these students also self-reported that they were average college students with a grade point average of between 2.5 and 3.5 (63%). This sample consisted of primarily undergraduate students: freshman (15%), sophomores

(13%), juniors (35%), seniors (33%), and graduates (4%). Many of these participants completed this survey at the end of the spring semester during a freshman level mathematics course (Critical Thinking in Mathematics).

The Pre-Ed Group also included some juniors who completed the survey at the beginning of their first educational psychology course and designated that they had completed no more than one mathematics methods course. These participants completed the survey in either the spring semester or summer semester of 1999. Although this group seems somewhat heterogeneous, a statistical comparison of those who had completed one mathematics methods course with those who had completed no mathematics methods courses revealed a statistically significant difference on only four of the 83 items in the survey. Hence, these students fit into the same group compatibly.

The second group (Early Ed) of participants included 43 students who had completed most of the coursework in at least one professional education course (either Child/Adolescent Developmental Psychology or Learning/Cognition/Motivation). Some of these participants had also completed most of the course work in both educational psychology courses. A few of the participants in this group also designated that they had completed the first of the three sequenced elementary mathematics methods courses. None of these were enrolled in the second mathematics methods course at the time of the survey. Of these students, ninety-eight percent were female and 58% considered themselves average math students (good, 26%, poor 12%). The majority of these students also self-reported that they were average college students with a grade point average of between 2.5 and 3.5 (62%). This group consisted of primarily juniors (65%) and seniors (30%), the rest were graduates. These participants completed the survey in November of 1998.

The third group (Mid-Ed (F)) of participants also completed the survey in November, 1998. This group contained 43 students from two sections of the same mathematics methods class. These students had just completed the coursework in the second of the three course elementary mathematics methods course sequence. Most had also completed both of the educational psychology courses. These mathematics methods classes were instructed by the same instructor, a male graduate student in mathematics education who completed his Ph.D. the next month. Only one of the participants in this group was male and all considered themselves good (43%) or average (57%) math students. Ninety-five percent of these students were seniors and the others were graduates.

The fourth group (Mid-Ed (S)) of participants was similar to the other Mid-Ed group. These students (n=39) completed the survey in the Spring of 1999. All participants in this group had also completed the coursework in the second mathematics methods course, but under a different instructor. This instructor was a female mathematics education graduate student who was also nearing completion of her Ph.D. All of these students were female. This group consisted only of juniors(33%) and seniors (67%) and all were average (54%) or better college students.

The fifth group (Full Ed) consisted of 41 students who completed the survey in the spring of 1999. All of these students were seniors (93%) or graduate (7%) level students. These prospective teachers had completed all six professional education courses and all three elementary mathematics methods courses required by the university to satisfy requirements for graduation. These students had also completed all of the field experience components, but had not yet begun their student teaching experience. To become certified in elementary education these students would still need to complete a semester of student teaching internship. Members of this group came from two sections of the third mathematics methods course taught by the same instructor. This instructor was a female mathematics education graduate student, nearing completion of her Ph.D. Two of the students were men. All considered themselves average (58%) or better college students. In spite of that, 12% considered themselves poor mathematics students (average, 49%, good, 39%). Because of the sequencing of the mathematics methods courses, some of the students who completed the survey in this section may have also completed the survey in the Mid-Ed (F) section. However, the profiles and demographics were somewhat different between the two.

From the two hundred twenty-six original participants, 14 were dropped from the final analysis. These participants were inconsistent with any group. For example, one freshman from the mathematics class indicated that she had completed all three mathematics methods courses. This may have been a misunderstanding on the student's part as to what a mathematics methods course is. Thus such inconsistencies on the information sheet triggered a red flag and dropping of that participant. In addition, some participants failed to fill out all items and this resulted in the statistical software package removing them from the analysis. Table 2 summarizes each group and the time of collection. Following the table, the procedure for coding and analyzing the data is discussed.

Table 2: Participant Groups

Group	Number	Date collected	Description
Pre-Ed	46	Spring/Summer 1999	-no professional education coursework -at most, one math methods course
Early Ed	43	Fall, 1998	-one or both educational psychology courses completed -at most, one math methods course
Mid-Ed (F)	43	Fall, 1998	-two math methods courses completed -one or both educational psychology courses
Mid-Ed (S)	39	Spring, 1999	-two math methods courses completed -one or both educational psychology courses
Full Ed	41	Spring, 1999	-both educational psychology courses completed -all three mathematics methods courses completed

Data Analysis

Item responses were coded into SPSS 8.0 exactly as they appeared on the instrument. Because items on the instrument appeared in two different forms, some worded positively and some items worded negatively, the negatively worded items were recoded or reverse-scored. This enabled a consistent scoring such that a positive attitude, higher self-efficacy, more constructivist pedagogy, and more sophisticated epistemology would incur a higher mean average. Once the data were coded and cleaned, three types of data analyses were conducted.

Descriptive statistics were computed on all groups. Means, Standard Deviations, Ranges, Minimum/Maximum scores, Skewness, and Kurtosis scores were computed on each of the nine subscales. Next, correlations using Pearson's Product Moment Analysis (Gall et al., 1996) were computed for aggregated means (mean of the mean) among each of the nine subscales for all groups. Results from the descriptive statistics and correlation statistics appear in Chapter IV.

Finally, Multivariate Analysis of Variance (MANOVA) scores were computed using the five groups as the fixed factor (independent variable) and the nine subscale means as the dependent variables. As recommended in research literature (Tabachnick & Fidell, 1996), follow-up univariate ANOVA values were computed in order to examine group differences on individual dependent variables. Post Hoc results were examined using the Tukey's HSD statistic in order to examine pairwise statistical differences. For each of these analyses, additional statistics were computed in order to verify that the assumptions of each analysis were satisfied. These included normality (Skewness, Kurtosis) and homogeneity of variance (Levene's test). Results of all statistical tests are reported in Chapter IV. A summary of each research question and the related measure and statistic follows:

1. What are the beliefs about mathematics held by preservice elementary and early childhood teachers before, during, and after completion of teacher preparation coursework? Descriptive statistics (means, standard deviations) were calculated for each of the five groups of preservice teachers on each of the nine dependent variables from the survey questionnaire.

2. What are the relationships among the attitudes and personal, pedagogical,and epistemological beliefs at each of the four levels of the teacher preparation program? Correlational statistics (Pearson's Product Moment) were calculated among the nine variables for each of the five groups.

3. Do the patterns of relationships among the attitudes and personal, pedagogical, and epistemological beliefs of students at the four levels of the teacher preparation program differ? All nine variables were compared among all five groups at the same time to determine if a significant difference existed among the group/variable patterns. This was accomplished using the MANOVA technique. Since an omnibus F revealed a significant difference in patterns, it

was important to further analyze how these patterns differed. Thus, followup ANOVA statistics with Tukey's HSD Post Hoc tests were computed.

In the following chapter, the results obtained from the data collection and statistical tests will be discussed.

CHAPTER IV

RESULTS

Three research questions guided the current study:

1. What are the beliefs about mathematics held by preservice elementary and early childhood teachers before, during, and after completion of teacher preparation coursework?
2. What are the relationships among the attitudes and personal, pedagogical,and epistemological beliefs at each of four levels of the teacher preparation program?
3. Do the patterns of relationships among the attitudes and personal, pedagogical, and epistemological beliefs of students at the four levels of the teacher preparation program differ?

This study was undertaken to determine what beliefs preservice teachers hold about what is effective mathematics teaching and their ability to become effective mathematics teachers. In addition, the study examined the trends in systems of beliefs held by different populations of preservice elementary and early childhood teachers. An important issue was to establish whether these trends differed significantly among the different populations. Specifically, do cross-sections of populations of elementary and early childhood education students, examined before, during, and after completion of formal teacher preparation training, differ significantly on their attitudes toward mathematics, and their personal, pedagogical, and epistemological beliefs?

To examine these issues, data were gathered over a three semester period from fifteen sections of students enrolled in either mathematics, mathematics methods, or professional education classes. Participants were grouped into five categories based on educational experience and time of taking the survey (one early group, three intermediate, and one advanced group). Means of individual survey items were aggregated into nine subscales intended to measure the five variables (one attitude subscale, two efficacy subscales, three outcome expectations subscales, two pedagogy subscales, and one epistemology subscale). The project used a quasi-experimental, multivariate design.

In this chapter, four major sections will be presented. First, evidence will be provided for the reliability and validity of the instrument used in the study. In the second section, descriptive statistics on the nine variables will be provided for each of the five groups of students. The third section includes correlational statistics among the nine variables for each of the five groups. The final section provides detailed analysis of significant differences in group trends. Included in this section are initial MANOVA findings and followup ANOVA results over the five groups and nine variables.

Reliability and Validity

The 83-item questionnaire was administered to students at five separate times. The first administration took place toward the end of the fall semester in 1998. Two sections of students who had completed all the coursework in the second of three mathematics methods classes and four sections of students who had completed the coursework in at least one educational psychology course took the survey at that time. At the beginning of the spring semester in 1999, two sections of students enrolled in an educational psychology course were given the survey before any coursework was completed. At the end of that semester, four sections of students enrolled in mathematics methods were administered the survey. Two of these sections had completed the second of three methods courses and the other two sections had completed all coursework and field experiences in both mathematics methods and professional education. Two more sections received the survey at the beginning of the summer semester of 1999. These students took the survey during a professional education course, but prior to any coursework. A total of 226 participants completed the survey.

Initial reliability scores were computed using the Pearson Product Moment Correlation coefficient over all 83 items and 226 participants. Missing cases were excluded pairwise. One hundred ninety-two cases were in the final analysis yielding an alpha level of .91. A second order factor analysis was then conducted on each subscale using the Principal Components Analysis Extraction method. Items that clustered into one component with Eigenvalues greater than one were examined and aggregated (mean of means) into variables for later analysis. These variables included: attitude toward mathematics and learning to teach mathematics (ATTITUDE=9 items, alpha=.88), self efficacy of ability to implement effective mathematics instruction (EFFICACY items, alpha=.85), efficacy in feeling prepared to teach mathematics (PREPARE=1 item), outcome expectations with respect to the belief about the control teachers have over student outcomes (OEXTCHCN=3 items, alpha=.64), expectations for the amount of effort involved in teaching mathematics (EFFORT=3 items, alpha=.78), outcome expectations as to whether the teacher preparation program has prepared them to teach effectively (TCHPREP=3 items, alpha=.62), pedagogical views with respect to traditional teaching (TRADPED=11 items, alpha=.91), pedagogical views with respect to constructivist teaching (CONSTPED=8 items, alpha=.82), and general epistemology about the nature of mathematics (GENEPIST=8 items, alpha=.78). A final full scale reliability using these 56 items yielded an alpha of .93. The initial reliability and subscale reliabilities are similar to those from the pilot study (see Appendix E).

A complete correlational analysis of the variables for all groups appears later in this chapter. A comparison of these results between groups, to those from the pilot study, and to those from theoretical literature appears to support the construct validity of the subscales.

Correlations

In order to establish how attitudes, personal, pedagogical, and epistemological beliefs held by preservice teachers about mathematics relate to one another, Pearson Product Moment Correlation statistics were computed among all nine variables for each of the five groups. Patterns of relationships varied among the groups. For complete correlation tables see Appendix E. In this section, only significant relationships will be discussed.

Pre-Teacher Education Group

For the Pre-Ed group of students, attitudes about mathematics and expectations that the teacher preparation program helped prepare them to teach mathematics did not significantly relate to any other variable. However, efficacy was found to significantly relate to five other variables: feeling prepared to teach math ($r=.62$, $p=.0001$), teacher control of student outcomes ($r=.45$, $p=.002$), expected effort in teaching math ($r=.32$, $p=.033$), constructivist pedagogical views ($r=.42$, $p=.005$), and epistemological views about the nature of mathematics ($r=.37$, $p=.013$). Besides being related to efficacy, epistemological beliefs were found to be significantly related to four other variables. These included: feeling prepared to teach mathematics (r=.49, p=.0001), expected effort in teaching mathematics (r=.31, p=.037), and both traditional (r=.43, p=.003) and constructivist pedagogical views (r=.52, p=.0001). Traditionalist pedagogical views were also found to relate to expected effort in teaching mathematics (r=.59, p=.0001). In addition, beliefs about feeling prepared to teach mathematics were found to be significantly related to constructivist pedagogical views (r=.30, p=.045).

Early Teacher Education Group

In the Early Ed group, attitude was found to be significantly related to traditional pedagogy (r=.32, p=.042). Traditional pedagogy was also found to be related to constructivist pedagogy (r=.38, p=.015) and epistemology (r=.45, p=.003). Efficacy was found to be related to feeling prepared to teach (r=.49, p=.001), outcome expectations for teacher control of student outcomes (r=.43, p=.004), constructivist pedagogy (r=.44, p=.004) and epistemology (r=.32, p=.038). Epistemology also related to teacher control (r=.49, p=.001) and constructivist pedagogy (r=.74, p=.0001). Constructivist pedagogy related to feeling prepared to teach and teacher control.

Fall Mid Level Teacher Education Group

In the Mid-level fall group, attitude was significantly related to two variables, feeling prepared to teach (r=.49, p=.001) and efficacy (r=.33, p=.035). Efficacy was also related to feeling prepared to teach (r=.37, p=.016). Feeling prepared to teach was also related to expectations of effort (r=.37, p=.015), confidence in the teacher preparation program (r=.32, p=.04), traditional pedagogy (r=.37, p=.027), constructivist pedagogy (r=.51, p=.001) and epistemology (r=.52, p=.0001). Effort expectations in teaching mathematics were related to teacher control (r=.39, p=.009), both traditional (r=.65, p=.0001) and constructivist (r=.37, p=.02) pedagogy, and epistemology (r=.59, p=.0001). Constructivist pedagogy was also related to traditional pedagogy (r=.68, p=.0001) and confidence in the teacher preparation program (r=.39, p=.001). Epistemology and traditional pedagogy were significantly related (r=.91, p=.0001).

Spring Mid Level Teacher Education Group

In the spring Mid-Ed group, attitude was correlated only to confidence in the teacher preparation program (r=.49, p=.002). Efficacy, on the other hand was related to several variables: feeling prepared to teach (r=.57, p=.0001), confidence in the teacher preparation program (r=.40, p=.01), constructivist pedagogy (r=.41, p=.01), and epistemology (r=.34, p=.03). Epistemology was also related to several other variables: teacher control of student outcomes (r=.40, p=.01), traditional pedagogy (r=.52, p=.001) and constructivist pedagogy (r=.61, p=.0001). Again, constructivist and traditional pedagogy were found to relate to one another (r=.43, p=.01).

Full Teacher Education Group

Like the other groups, the group which had completed all their teacher preparation courses and field experiences was found to have a different pattern. Attitude was found to relate to both feeling prepared to teach ($r=.54$, $p=.0001$) and confidence in the teacher preparation program ($r=.37$, $p=.02$). Efficacy was again found to relate to several other variables including feeling prepared to teach ($r=.57$, $p=.0001$), both traditional ($r=.42$, $p=.007$) and constructivist ($r=.54$, $p=.0001$) pedagogy, and epistemology ($r=.55$, $p=.0001$). Feeling prepared to teach was also found to relate to several variables: confidence in the teacher preparation program ($r=.59$, $p=.0001$), both traditional ($r=.42$, $p=.007$) and constructivist ($r=.31$, $p=.05$) pedagogy, and epistemology ($r=.46$, $p=.003$). Traditional pedagogy was found to relate to expected effort ($r=.52$, $p=.0001$), constructivist pedagogy ($r=.62$, $p=.0001$), and epistemology ($r=.65$, $p=.0001$). Finally, constructivist pedagogy and epistemology were also related($r=.81$, $p=.0001$)

Having looked at the significant correlations among the variables within each group, the next logical step was to establish whether these patterns differed significantly. To do this, a Multivariate Analysis of Variance and appropriate follow up tests were conducted. The next section discusses what was revealed from this analyses.

Trend Analysis

Gall et al. (1996) defined trend analysis as a longitudinal study in which a researcher attempts to describe change by selecting different samples at each data collection point from a population that does not remain constant. The focus of this investigation was to collect data from four cross sections of a single teacher preparation program over a three semester period. This was done in order to examine whether a trend in beliefs (variable means) seemed to evolve with respect to the level of teacher preparation.

The first step was to test the hypothesis that groups who experienced varying levels of teacher preparation training were significantly different. To do this, descriptive statistics (means, standard deviations) for all groups on all variables were generated and examined (see Table 3). In order to establish whether an overall group by variable difference existed, a Multivariate Analysis of Variance (MANOVA) was run using the group level as the fixed factor and the nine subscales as the dependent variable group.

Before the MANOVA results could be interpreted with confidence, the assumptions of that statistical technique needed to be addressed. The first three assumptions are: (1) the observations are normally distributed in each group, (2) the population variance for the groups are equal, and (3) the observations are independent (Stevens, 1990).

Independence of observation is assured by the research design. Students were administered the instrument during class periods under supervision of the researcher. All instruments were filled out individually and without consultation among participants.

Table 3

Means and Standard Deviations for All Groups

	Group	Pre-Ed	Early Ed	Mid Ed (S)	Mid Ed (F)	Full Ed
ATTITUDE	Mean	3.21	3.07	3.31	3.29	3.28
	SD	.83	.60	.68	.77	.69
EFFICACY*	Mean	3.79a	3.97ab	4.08abc	4.32c	4.21bc
	SD	.67	.48	.47	.59	.42
PREPARE*	Mean	3.02a	3.39ab	3.66b	3.88b	3.83b
	SD	.93	.84	.81	.77	.70
EFFORT*	Mean	2.97a	3.18ab	3.27ab	3.43b	3.21ab
	SD	.57	.57	.56	.61	.65
OEX TCHCN	Mean	3.79	3.91	3.84	3.91	3.63
	SD	.57	.61	.46	.63	.24
TCHPREP	Mean	3.72	3.76	3.84	3.61	3.84
	SD	.69	.61	.62	.77	.68
TRADPED*	Mean	2.77a	3.19b	3.86c	3.94c	3.77c
	SD	.81	.71	.49	.54	.65
CONSPED*	Mean	3.97a	4.04ab	4.33bc	4.44c	4.31c
	SD	.44	.47	.35	.41	.41
EPIST*	Mean	3.65a	3.88ab	4.04bc	4.22c	4.08bc
	SD	.47	.38	.31	.48	.47

Note. Values with shared subscripts (a,b, or c) indicate values which are not significantly different. ATTITUDE = attitude toward mathematics; EFFICACY = self-efficacy beliefs about the ability to implement effective mathematics instruction; PREPARE = feeling prepared to teach mathematics; EFFORT = expectation for effort in teaching mathematics; OEXTCHCN = outcome expectations for control of student outcomes; TCHPREP = expectations about the teacher preparation program; TRADPED = traditionalist pedagogical view; CONSPED = constructivist pedagogical views; EPIST = epistemological views about the nature of mathematics and learning.

*indicates significant differences found in variable

To address the assumption that observations were normally distributed, skewness and Kurtosis values were obtained and examined. All nine variables had skewness values between -1 and +1, and thus were considered to be approximately normal. Kurtosis values were acceptable.

To address the assumption that population variances were equal for the groups, Levene's statistical tests of homogeneity of variance were requested during analysis. On all except 2 of the tests, Levene's tests indicated that population variances were equal. When the hypothesis of equal variances in Levene's test is rejected, the ANOVA statistic is still robust when cell sizes are equal or approximately equal (Stevens, 1990). Cell sizes are considered approximately equal when the ratio of the largest cell to the smallest cell is less than 1.5. For this study the largest cell size was 46 and the smallest was 38 with a ratio of 1.21. Multivariate analysis has additional assumptions. These assumptions were also addressed.

Using the Wilkes' Lambda test, MANOVA revealed a significant overall difference in group patterns ($F(44,687)=3.20$, $p=.0001$), with a moderate effect size (eta squared=.16). Tests of univariate effects revealed significant differences in efficacy ($F(4,189)=6.12$, $p=.0001$, eta squared=.12), epistemological beliefs ($F(4,189)=10.62$, $p=.0001$, eta squared=.18), traditional pedagogical views ($F(4,189)=23.04$, $p=.0001$, eta squared=.33), constructivist pedagogical views ($F(4,189)=8.62$, $p=.0001$, eta squared=.15), feeling prepared to teach mathematics ($F(4,189)=6.324$, p=.0001, ES=.12), and outcome expectations on the amount of effort in teaching mathematics (F(4,189)=3.21, p=.014, ES=.06).

No significant differences were found in attitudes, outcome expectations on teacher control of student outcomes, nor on expectations for the effectiveness of the teacher preparation program. Effect sizes on these variables were from .002 to .05. Tukey's HSD was used to conduct pairwise comparisons on each of the significant variables by group.

Post Hoc comparison of the groups on efficacy revealed the Pre-Ed group (M=3.78) was significantly different than the Fall Mid-Ed group (M=4.32, p=.0001) and the Full Ed group (M=4.21, p=.004), but not significantly different than the Early Ed group (M=3.97) nor the Spring Mid-Ed group (M=4.08). The Early Education and Fall Mid-Ed groups also differed significantly (p=024). Figure 1 illustrates this trend.

With respect to epistemological beliefs about the nature and learning of mathematics, the Pre-Ed group (M=3.65) differed significantly from the Spring Mid-Ed group (M=4.04, p=.001), the Fall Mid-Ed group (M=4.22, p=.0001), and the Full Ed group (M=4.08, p=.0001), but not from the Early Ed group. The Early Education group (M=3.88) differed significantly from the Fall Mid-Ed group (p=.0003). Those groups which had completed two or more mathematics methods courses did not differ significantly from one another. Figure 2 illustrates the trend in epistemology.

Figure 1

Pattern of Group Means on Efficacy

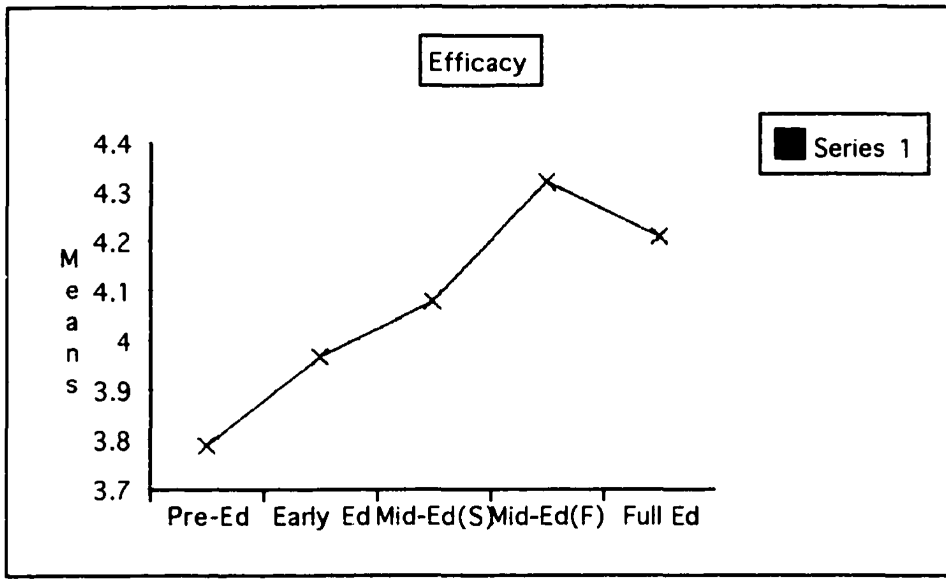
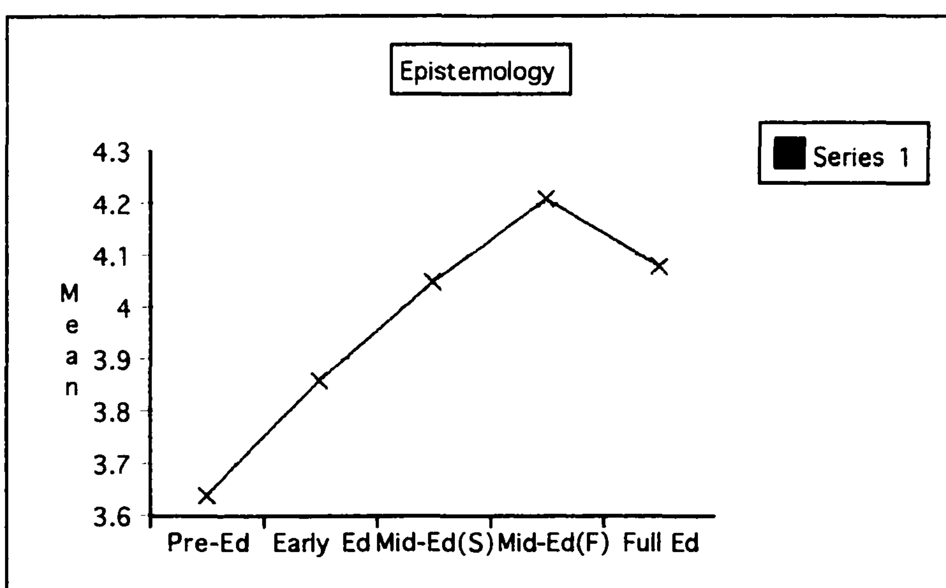


Figure 2

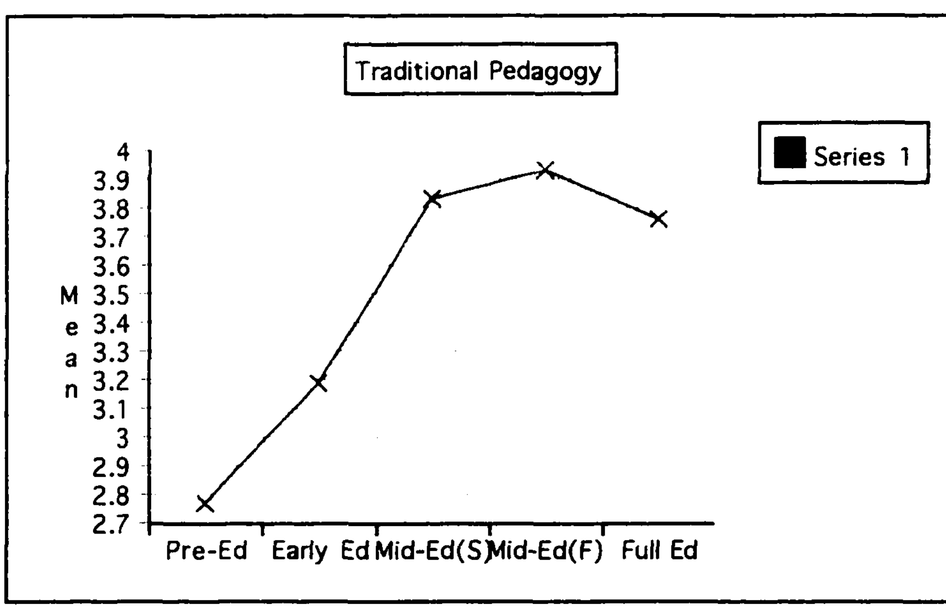
Pattern of Group Means on Epistemology



Significant differences in pedagogical beliefs were also observed among the groups. On traditional pedagogical views, again the Pre-Ed group (M=2.77) was significantly different than all other groups: Early Ed (M=3.19, p=.026); the Spring Mid-Ed (M=3.86, p=.0001); the Fall Mid-Ed (M=3.94, p=.0001); and, the Full Ed group (M=3.77, p=.0001). The Early Ed group was also significantly different than the Spring Mid-Ed (p=.0001), the Fall Mid-Ed (p=.0001), and the Full Ed group (p=.001). The Mid-Ed and the Full Ed groups did not differ significantly on this variable. Figure 3 illustrates the trend of the Means with respect to Traditional Pedagogy.

<u>Figure 3</u>

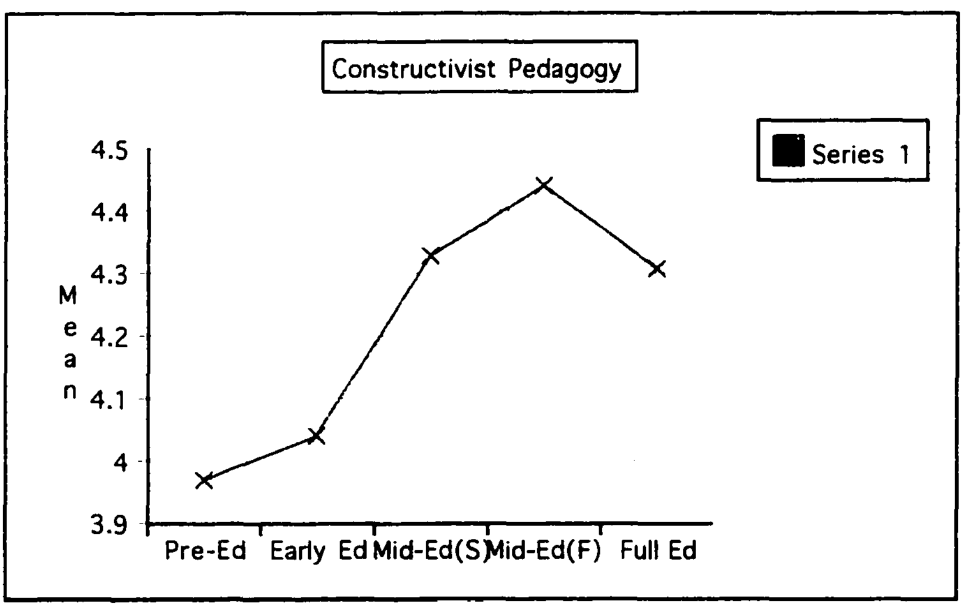
<u>Patterns of Traditional Pedagogy Means by Group</u>



On Constructivist pedagogical views, the Pre-Ed (M=3.97) and Early Ed (M=4.03) groups did not differ from one another, but differed significantly from all other groups. Again, the Mid-Ed and Full Ed groups did not differ significantly from one another, but showed a progressive increase in mean scores. The significance levels between the Pre-Ed group and the others were as follows: Spring Mid-Ed group (M=4.29, p=.009), the Fall Mid-Ed group (M=4.44, p=.0001), and the Full Ed group (M=4.32, p=.002). The Early Education group differed significantly from the Fall Mid-Ed group (p=.0001) and the Full Ed group (p=.0320. Trends on means of the preservice teachers' beliefs about constructivist pedagogy is illustrated in Figure 4.

Figure 4

Patterns of Constructivist Pedagogy Means by Group



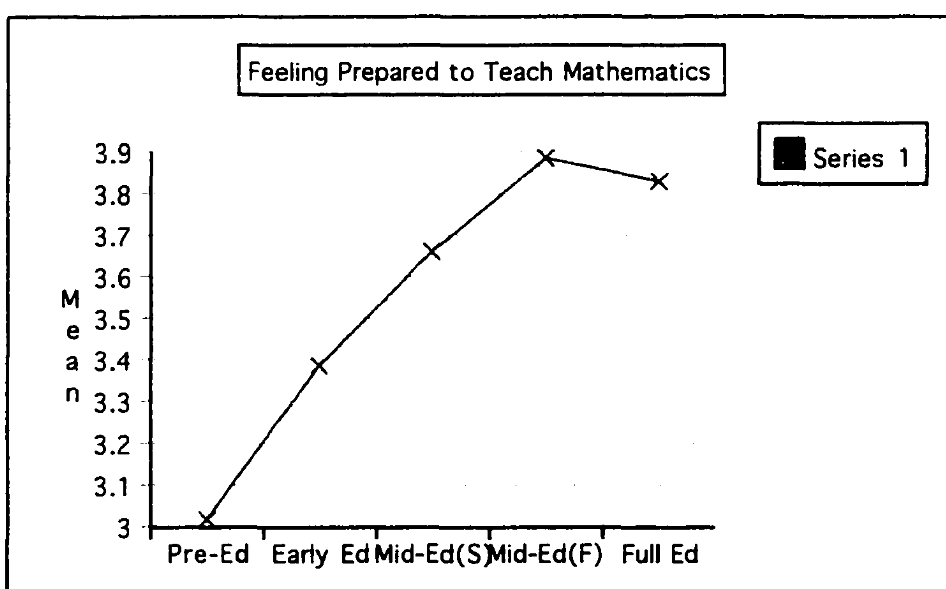
On beliefs about feeling prepared to teach mathematics, the Pre-Ed (M 3.07) and Early Ed groups (M=3.39) did not differ significantly from one another. However, the Pre-Ed group differed significantly from the Spring Mid-Ed (M=3.61, p=.045), the Fall Mid-Ed (M=3.87, p=.0001), and the Full Ed (M=3.82, p=.0001). The Early Ed group and the more experienced groups did not differ significantly from one another, but again showed a progression in mean values as a function of educational experience. The trend of the means of the groups on feeling prepared to teach mathematics is illustrated in Figure 5.

Figure 5

Patterns of Group Means

on Beliefs

About Feeling Prepared to Teach Mathematics

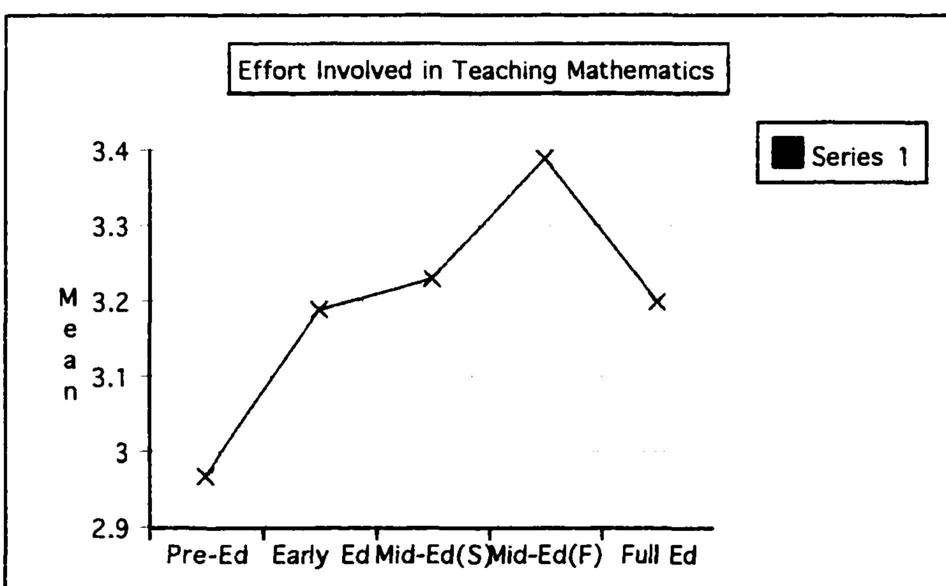


On two of these expectation subscales, there were no significant differences among the groups. These were the outcome expectations for teacher control of student outcomes and the expectations that the teacher preparation program was doing an adequate job. However on expectations for the amount of effort in teaching mathematics, significant differences did appear. The Pre-Ed group (M=2.97) differed significantly from the Fall Mid-Ed group (M=3.43, p=.004), but not from the Early Ed (M=3.18), the Spring Mid-Ed (M=3.27), nor the Full Ed (M=3.21). None of the groups who had any educational experience at all differed from one another on this variable. Figure 6 illustrates the patterns of means on this variable.

Figure 6

Patterns of Means on Beliefs

About the Effort Involved in Teaching Mathematics



To summarize, differences were seen in patterns of correlations between variables. Patterns of beliefs were found to differ significantly among the groups. In the following chapter implications of these statistical findings will be discussed.

CHAPTER V

DISCUSSION AND CONCLUSION

Discussion

The results of this investigation into the beliefs held by preservice elementary and early childhood teachers about mathematics and mathematics instruction provided direct answers to each of the three research questions that guided the study. The research questions focused on gaining a greater understanding of the beliefs of prospective teachers at various points in their development as teachers in one progressive teacher education program. The beliefs of interest included attitudes toward mathematics, epistemological beliefs about the nature of mathematics, pedagogical beliefs about what is effective mathematics teaching, efficacy beliefs about their ability to become effective mathematics teachers, and expectation beliefs about the implementation of effective teaching in mathematics. A comparison of the beliefs of the preservice teachers at different points in their educational experience revealed a positive trend in efficacy, a trend toward a more constructivist pedagogical view of teaching, and a trend toward a more sophisticated epistemological view about the nature of mathematics. Thus, this study provided some insights as to the evolution of the belief systems about mathematics of preservice elementary and early childhood teachers during this teacher preparation program.

The reliability of the questionnaire items used in this project was consistent over the three semesters examined and was strong in each case. Items from the questionnaire were adapted from two main sources and were adapted to fit preservice teachers in the domain of mathematics. The internal reliability scores of the adapted questionnaire were also consistent with those found in the original studies (Curda, 1997; McGinnis et al., 1997, 1998). In addition, the correlations among the variables support the theoretical and empirical work done by other researchers of the same general topic (Bandura, 1977, 1988; Fleener & Nicholas, 1994; Nicholas & Fleener, 1994; Schommer, 1990, 1994). With these points in mind, this chapter concentrates on the specific results found on the belief systems of the preservice participants of the current study. The discussion of the results and conclusions from these results has been followed by a brief discussion of the implications these findings have to the current body of knowledge about prospective teachers' belief systems and how they relate to teacher preparation programs.

<u>Belief Systems by Group</u>

Four main levels of preservice teachers were examined over three semesters. The first group (Pre-Ed) consisted of students who had experienced very little if any formal training in teacher preparation. These participants were surveyed during either a freshman mathematics course or on the first day of class in a professional education course. Although some students indicated they had completed one mathematics methods course, they remained in this group with those who primarily had completed no mathematics methods courses. The rationale for this was twofold. First some of the students were very early in their educational program and it is not likely that they had completed a more advanced course (e.g., a freshman would probably not have completed the junior level first mathematics methods course). Some early students may not yet have understood that mathematics and mathematics methods were different types of courses. More importantly, an independent T-test statistic comparing the students who had marked that they had completed one mathematics methods course with those who indicated they had not completed any mathematics methods courses revealed no significant difference on 79 of the original 83 items in the questionnaire. No two of the four significantly different items fell into the same variable, so this had little impact on final variable outcomes. Thus, this group still can be viewed as having no formal teacher training.

The second level within the groups (Early Ed) consisted of students who had completed at least one professional education course and no more than one mathematics methods course. These students completed the questionnaire during the last weeks of a professional education course in the fall semester of 1998. A few students in the original sampling of this group indicated they had completed more than one mathematics methods course and were eliminated from the group in order to make it more homogeneous.

The final three groups were all sampled during the last week of the fall or spring semester. Two of these (Mid-Ed) had just completed the second of the three required mathematics methods courses. The other (Full Ed) group had just completed the third methods course. This group had also completed all professional education courses and all field experiences except student teaching. All of the groups were taught by different instructors.

An examination of the descriptive statistics for the Pre-Teacher Education group over the five variables (nine subscales) indicated that their attitudes toward mathematics and learning to teach mathematics (ATTITUDE) was slightly above the median score of 3. This implied a mean attitude that was primarily neutral with a slight leaning toward positive feelings. A similar neutral mean score appeared on another variable, the students' feelings about being prepared to teach math (PREPARE). However, their feelings of efficacy that they could become effective mathematics teachers (EFFICACY) was much more positive, with the mean score falling just below 4 (agree). In addition, their expectations that their teacher preparation program would help them achieve this (TCHPREP) was at the same positive level.

The Pre-Ed group also revealed an interesting pattern on the other two expectations variables. Their mean score on expected effort in teaching mathematics (EFFORT) was slightly below the median, indicating that the expected effort in teaching math would be about the same as other types of courses or even a little less. The mean score on teacher control of student outcomes (OEXTCHCN) was much above the mean, indicating a fairly strong belief that teachers are responsible for student achievement.

This group of pre-teacher education students also displayed an interesting pattern on their pedagogical views about teaching mathematics. They had the strongest beliefs among all the groups that math should be taught traditionally (TRADPED). According to Raymond (1997), the traditional viewpoint on teaching mathematics holds that the teacher's role is to lecture and to dispense mathematical knowledge. The teacher seeks "right answers" and is less concerned with explanations. Memorization of skills and facts is emphasized and mastered through drill and practice. Instruction very closely follows the textbook. In the traditional view of teaching, the student is also viewed differently. In general, students passively receive knowledge from the teacher. Students usually receive whole group instruction and then work individually. Drill worksheets are often used rather than hands-on conceptual activities (Ernest, 1989; Raymond, 1997).

On the beliefs about traditional pedagogy variable, the lower the score the more traditional the viewpoint. This group was the only group who scored below the median for this variable.

On the other hand, beliefs of the pre-teacher education group about constructivist pedagogy in mathematics were well above the median, although significantly below those of the mid level and full teacher education students. This is somewhat of an enigma, since they profess a belief in teaching mathematics traditionally, but seem to indicate a receptiveness to constructivist ideas. In speculating on an explanation for this, the background of the students may give a clue.

Since the pre-teacher education group had completed no formal teacher preparation training it would be anticipated that they would expect to teach mathematics like they were taught (Fleener & Nicholas, 1994; Foss & Kleinsasser, 1996; Smith, 1996). Many of these students were probably taught in the traditional manner. However, for more than a decade the NCTM (1989, 1991) has encouraged a more constructivist leaning in teaching mathematics. The group's pattern of higher mean scores on constructivist belief may indicate they may have had teachers who were trying to follow the NCTM recommendations. Or, it may have been that they liked the ideas represented in that section of questions. These ideas included asking students to reflect on their mathematical thinking, discuss explanations, use technology, and work in small groups. Pedagogical views about how a subject should be taught often reflects one's epistemological views about the nature of the subject being taught (Schommer, 1990, 1994). The pre-teacher education group not only had the lowest mean scores on pedagogical views but on epistemological beliefs (GENEPIST).

When examining high school and college age students, Schommer (1990, 1994) found distinct levels in epistemological beliefs. She theorized that students progressed from a naive epistemological pattern of beliefs to a more sophisticated pattern as they gained educational experience. Consistent with that theory, mean scores in the study addressed in this paper also increased (implying more sophisticated beliefs) as students gained educational experience. The Pre-Ed group, the most novice students, were found to have the lowest mean score on epistemological beliefs about the nature of mathematics. However, although it was the lowest mean score among the groups, it was above the median, indicating a slightly more sophisticated view of the nature of mathematics. Schommer argued that in a naive epistemological view, knowledge was thought of as certain, often in isolated parts, and handed down by authorities. She also stated that in this view, knowledge must be learned quickly in order to be learned at all. The more sophisticated view looks at knowledge as uncertain, changeable, and is often mastered only with effort and long persistence. Relating this to the domain of mathematics, the traditional (naive) epistemological view on the nature of mathematics holds that it is an unrelated collection of facts, rules, and skills, and that it is fixed, predictable, absolute, certain, and applicable. Whereas, the nontraditional (sophisticated) view holds that mathematics is dynamic, problem driven, and continually expanding and can be surprising, relative, doubtful, and aesthetic (Ernest, 1989; Raymond, 1997). While most of the students in the Pre-Ed group had no teacher training experience, all of the students in the other groups had at least some teacher training. Mean Scores on all variables were seen to increase as a function of teacher training educational level. Students who had completed their teacher training program differed significantly from the Pre-Ed on six of the nine subscales. These students had a very high self-efficacy related to their ability to teach math effectively. They felt prepared to teach math, held more constructivist and less traditionalist pedagogical views, and were more sophisticated in their epistemological view on the nature of mathematics. While they did not differ from any other group on their attitudes toward mathematics, their attitudes were not negative. All group means were slightly above the median. Likewise the full education group did not differ from any other group on their expectations that the teacher education program was preparing them to teach mathematics effectively. All groups' mean scores on this variable were well above the median. Another area where no significant differences were found was in outcome expectations for teacher control of student outcomes. All groups' mean values were well above the median. This indicates a feeling among all these prospective teachers, no matter what their educational experience, that they will be responsible for what their students learn. Returning to the variables on which significant differences were seen, three of these bare closer examination.

On three of the variables where significant differences were found, the full education group had very strong mean scores, between 4 (agree) and 5 (strongly agree). These were efficacy, constructivist orientation, and epistemological views. These students felt very capable of implementing effective mathematics instruction to elementary students. In addition, they had adopted strongly constructivist views toward teaching mathematics. Finally they regarded mathematics as a consistently expanding field in which connections between disciplines should be emphasized.

The NCTM (1989, 1991) standards encourage a more constructivist orientation in which teaching is more student centered and addresses conceptual understanding, logical reasoning, and fundamental understanding rather than rote memorization, and connections are made across disciplines. In addition, an epistemological view of mathematics as a dynamic branch of science is also advocated. The higher mean scores of the full teacher education students in constructivist orientation and epistemological views on the nature of mathematics indicates a strong movement of the students in the direction encouraged by the NCTM.

In addition to the marked contrast between the pre-teacher education students and the full teacher education students, the intermediate levels of teacher education showed consistent progression in mean scores. The early teacher education group had completed at least one semester in the teacher preparation program. The descriptive statistics for this group showed increases on all variable mean scores. Even though they did not differ significantly from the pre-educational group on any score, they also did not differ significantly from the mid level groups which often did differ significantly from the pre-education group. In other words, they often seemed to have a transition score which was higher than the pre-education group and lower than the mid level group, while not statistically different than either.

The two mid education groups differed little from one another. The only variable on which they differed significantly was epistemology. The fall group showed a more sophisticated level on their mean score. In addition, while not significantly different, the fall group showed higher mean scores on all variables than the spring group. The fall group was, however, significantly higher than the pre-education group on the expected effort involved in teaching mathematics. A closer examination of the two mid level groups revealed some interesting differences.

Although both groups had just completed the second of three mathematics methods courses, the fall group was composed of ninety-five percent seniors; the rest were graduate students. The spring group had only sixty-seven percent seniors, thirty-three percent juniors and no graduates. All of the fall group considered themselves average or better at mathematics, while the spring group had eight percent who considered themselves poor math students. The classes were taught by different instructors. The fall class was taught by a male graduate student who completed his PH.D. shortly after the class. He had taught this class previously. The spring class was taught by a female graduate student who had not taught the class before.

In all cases, mean scores which differed significantly among the groups increased as a function of educational level. In addition, most mean scores were above the median, indicating positive attitudes, somewhat sophisticated epistemological beliefs, constructivist orientations to pedagogy, and good self-efficacy with respect to the ability to implement effective mathematics instruction. In the following section how these variables related to one another will be discussed.

Correlations Among Variables

Bandura (1977, 1986) theorized that efficacy and outcome expectations are the strongest predictors of effort a person invests in a task and persistence at a difficult task. Efficacy deals with one's belief in his/her ability to accomplish a task, while outcome expectations deal with the belief that actions taken will produce the desired results. Researchers have also connected efficacy to teachers' actions in the classroom (Ashton, 1985; Ernest, 1989; McDevitt, Heikkinen, Alcorn, Ambrosio, & Gardner, 1993; Pajares, 1992). Consistent with these theoretical and empirical findings, the current study also found efficacy to be related to more variables than any other variable in all groups except one.

In the Pre-Ed group, efficacy was found to be correlated to feeling prepared to teach mathematics, beliefs that teachers control student outcomes and constructivist pedagogy. Efficacy was also found to be significantly correlated to epistemology and the expected effort in teaching mathematics. Thus, for this group, the feeling that they had the ability to learn to be effective mathematics teachers covaried with their beliefs that they would be prepared to teach mathematics and that they would have control over students' learning. In addition, the above median efficacious feelings and below median effort expectations in teaching mathematics may imply that this group believes teaching mathematics will not be too effortful and that they feel confidence in their ability to invest the effort that it will take to be effective mathematics teachers. This group also showed a very strong relationship between epistemological views and constructivist pedagogical beliefs. Thus, the more sophisticated the views on the nature of mathematics, the more constructivist the viewpoint. In addition, a very strong relationship existed in this group between traditionalist pedagogical views and the expected amount of effort involved in teaching math.

The relationships between variables seemed to be unique to groups. In general, no consistent pattern of relationships emerged as a function of educational level. In the early education group, as well as the two spring semester higher level groups, efficacy remained the variable correlated to more variables than any other. In all of those groups, efficacy was significantly related to feeling prepared to teach mathematics, constructivist pedagogical beliefs, and epistemological beliefs about the nature of mathematics and learning. In the fall semester mid level group, efficacy was not the variable which related the most to other variables. It did still relate to feeling prepared to teach as well as attitudes toward mathematics.

In the fall mid level group, the variable most related to other variables was effort expectations in teaching mathematics. This variable was found to be significantly related to feeling prepared to teach, traditional and constructivist pedagogy, and epistemological views on the nature of mathematics and learning. Interestingly, effort was not significantly correlated to any other variable in the spring mid level class, nor the full education group.

While patterns of correlations seemed to be idiosyncratic by group, yielding no real insight, patterns of differences between variables by group painted a much different picture. In the following section, these group trends will be discussed.

Comparison of Group Patterns

A comparison of the means of all the variables among all five groups was computed using the MANOVA statistical technique. This analysis revealed a significantly different overall pattern of beliefs among the groups. Followup analyses revealed the same trend in all significant variables. Attitudes, outcome expectations for teacher control in student outcomes, and expectation beliefs about the impact of the teacher preparation program did not differ significantly among the groups.

Variables which differed significantly included feelings of self-efficacy, epistemological views about the nature of mathematics and learning, both constructivist and traditionalist pedagogical beliefs, and beliefs about being prepared to teach mathematics. In all cases, there was a positive trend with the mean scores of the variables varying directly with the amount of teacher preparation. In other words, the least experienced groups had the lowest means, and the more teacher preparation, the higher the means.

In summary, the most inexperienced students (Pre-Ed group) had the lowest means. The mean scores of students who had completed at least one educational psychology course and at most one mathematics methods course were higher on all variables where significant differences were found among the groups. Their scores seemed to be transition scores. Students who had completed most (Mid-Ed) or all (Full Ed) of the program were generally not significantly different from one another, but were usually significantly higher than the less experienced students. In all cases, mean scores increased as a function of educational level. Correlations among beliefs varied from group to group, but in most cases, efficacy and epistemological beliefs seemed to relate to more variables than any other construct. Patterns of beliefs were significantly different in the more experienced students than those with less educational experience. This occurred regardless of the semester in which the data were collected or the instructor. In the following section, implications of these results will be discussed.

Conclusion

The design of this investigation was quasi-experimental and was conducted using a purposive sample from one teacher education program. Therefore, the results should be interpreted with caution and not generalized beyond the sample. However, strong implications do appear consistently throughout the study. Participants in the sample came from fifteen sections of six different classes. These included a freshman level mathematics class, two different professional education courses taught under three different instructors, and two different levels of mathematics methods courses under three different instructors. Data were collected over three semesters. Regardless of the semester, instructor, or course, the trend was clear. Students who had participated in the elementary teacher education program were significantly different from those who had not or who had just begun. By the time the students had completed the program, preservice teachers had significantly more positive self-efficacy with respect to their ability to effectively teach elementary mathematics. These students also reflected a strong adoption of the NCTM recommended constructivist orientation toward teaching mathematics. Finally, the students showed a very sophisticated epistemological view on the nature of mathematics as a dynamic, ever changing, problem driven branch of science. These reflective, critical thinking beliefs are expressed as an overarching goal of that teacher education program. This program encourages the growth of this reflective, critical thinking process in several ways.

Students explore notions of what mathematics is as they develop understandings and perspectives of children's learning of mathematics. In addition, the prospective teachers create a developmental portfolio beginning in their first mathematics methods course. This is maintained throughout the program. Through their developmental portfolios they are asked to reflect on and critique their own mathematics experiences as they compare them to the experiences they are having during school visits. These visits are an important aspect of the program as the prospective teachers have many hours of interaction with students in the mathematics classroom. These developmental field experiences provide further opportunities for reflection and praxis as students engage in interaction with children learning mathematics. The positive results found in this study are consistent with those found in empirical research on programs which had attitudes and beliefs as a specific goal. Two such programs can be compared to this study.

In the McDevitt et al. study (1993), the enhancement of preservice teachers' attitudes and beliefs were explicit goals of the teacher preparation program. While the MeDevitt study cannot be directly compared to the current study, certain commonalities can be considered. The beliefs examined were slightly different and different scales were used. However, that study showed significantly better attitudes toward teaching math at the end of the cohort program when participants were compared to noncohort controls. Participants' beliefs on the most important components of effective mathematics teaching were also measured. The McDevitt participants indicated these practices included hands-on activities, refraining from an overuse of drill, integrating subjects, emphasizing problem solving, and utilizing cooperative groups. These were collected in a qualitative manner and compared against control groups.

The types of effective teaching methods mentioned by the McDevitt participants were measured directly in the current study. Thus the positive beliefs exposited in the McDevitt study were also highly valued by students involved in the teacher education program of concern to this study. These practices were examined in the constructivist and traditional pedagogical sections of the questionnaire. Students who had completed most or all of the teacher preparation program had significantly higher means on these items than those who had not. Thus the results from the current study seem equally as optimistic as those found in the McDevitt study.

Another study which shared many similarities to the current study was the McGinnis et al. (1997, 1998) study. In that study, the Maryland Collaborative for Teacher Preparation (MCTP) looked at the attitudes and beliefs of preservice teachers about teaching math and science. Many of the items used in the questionnaire of the current study were revised from the MCTP questionnaire.

A goal of the MCTP was to promote the constructivist ideology advocated by the NCTM and National Academy of Science (McGinnis et al., 1997). Further goals were to promote positive attitudes toward math and science and to develop professional teachers who were confident in their ability to teach math and science. The results of the McGinnis study can be somewhat more closely compared to the results of the current study. Some items were similar and the subscales were somewhat similar, although the McGinnis study looked at two domains simultaneously. The mean score on beliefs about the nature of math and science for the MCTP students was 3.98 on a scale of one to five. This scale was similar to the epistemology variable of the current study.

On the one to five scale in the current study, the epistemology scores for the Mid-Ed and Full Ed groups ranged from 4.03 to 4.21.

Beliefs about the teaching of math and science was another variable measured in the McGinnis et al. (1997) study. Again some items measuring this variable were similar, but some differed from the current study. However the goal being measured was similar, namely to measure the extent to which students were adopting the beliefs promoted by the Standards in each domain. Students in the McGinnis study obtained a mean of 4.11. The constructivist subscale of the current study came closest to measuring the same construct. Mean scores of the Mid-Ed and Full Ed students ranged from 4.36 to 4.44. Other variables measured by the McGinnis and the current study were not similar in nature. Again, the students of the current study showed results consistent with those of a study designed to measure attitudes and beliefs as a direct goal of a teacher preparation program.

What could explain the trend seen in this study? Only a few plausible explanations can emerge. The first and most obvious is that the teacher education program is having a significant influence on preservice teachers' beliefs about what is effective teaching of mathematics in elementary school and their ability to implement it. Again, we caution about the limitations of the study. A second explanation might be a natural maturing process as a result of general educational experience. A comparison would need to be made of students in the elementary education program with a control group of students not involved in education. This is a topic for later research. Other topics for further research will be discussed in the final section of this chapter.

A summary of the conclusions of this study follows:

1. The group with the least educational experience (Pre-Ed) showed the lowest mean scores on all variables. Most scores were at or above the median level for this group. This group showed neutral scores on attitude and feeling prepared to teach math. They believed mathematics should be taught in a traditional manner, but showed a slightly positive mean on constructivist viewpoints. Their epistemological beliefs were above the median, being slightly higher than what Schommer (1990, 1994) called naive epistemology.

2. Correlations between variables indicated that efficacy and epistemology were the two variables which correlated more frequently to other variables. Attitudes were also correlated to different variables in each group.

3. There was a significant difference in the patterns of variables between all groups considered simultaneously.

4. All variables which had significant differences between groups showed a trend of increase as a function of educational level. The higher the educational level of the preservice teachers, the more efficacious, constructivist, and sophisticated are their epistemological views.

An examination of the correlations and trends in the evolution of this group of preservice teachers indicated that attitudes are related to varying beliefs among the different levels. However mean attitude scores were not significantly different among the groups. In all cases attitudes were at the neutral or slightly positive level. The optimistic side of this is that attitudes toward math were not negative and that attitudes did not influence actions in other areas.

It has long been known that efficacy is an important aspect in a person's actions and behaviors. The results of this study were consistent with previous research in that area. An important issue that emerged in this investigation is that of epistemology. Both efficacy and epistemological beliefs seemed to be the variables which related, in all groups, to many other variables. Both of these variables differed significantly with respect to the amount of teacher training. In the next section suggestions related to these new findings are iterated.

The design of the current study was quasi-experimental, using a purposive sample of preservice teachers, in one teacher preparation program. Results should be interpreted with caution. Generalization to a wider population should not be assumed. However, the results are positive and should be considered as one more piece of evidence that students who have participated in the professional teacher training program are beginning their teaching careers reflecting on what is effective teaching in mathematics and their ability to implement it.

Suggestions for Future Research

In this investigation, the assumption was made that most teacher education programs have, in one form or another, goals that are related to student beliefs regarding teaching and learning. In these programs, the effectiveness of the teacher education curriculum in reaching these goals will be mediated by the student's initial belief systems and the beliefs they develop throughout their programs of study. A primary focus of this investigation was to develop an understanding of the dynamics of belief systems. Such an understanding may be one more factor contributing to the development of prospective teachers who approach the teaching of mathematics with positive attitudes toward mathematics, who feel efficacious about their ability to implement effective instructional techniques, and who can reflect critically on their beliefs about the different orientations to teaching mathematics at the elementary level.

Further examinations of the types of attitudes and beliefs which impact behaviors is warranted. Longitudinal studies which examine the evolution of these beliefs as the preservice teachers gain educational experience may contribute further insight into the development of motivated teachers of elementary mathematics. Most of the young people entering elementary education are female. Gender was not considered in this investigation, but given the research (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Greene, DeBacker, Ravindran, & Krows, 1999) that still indicates the hard sciences are considered male domains, this is another important issue to examine further. Continuing to develop new and better ways of measuring these beliefs is of importance. Another important aspect to continue to explore is that of epistemological beliefs about the nature and learning of mathematics. A final topic to be considered in research is a comparison of beliefs and attitudes of students who are progressing through the elementary education program to those who are not involved in education. Clear trends were observed in this study which showed an evolution of beliefs toward more positive self-efficacy, more constructivist orientations to pedagogy, and more sophisticated epistemological beliefs about the nature of mathematics as preservice teachers gained more experience in teacher training. However, whether this was a direct result of a progressive teacher education program or some other process must remain as an unanswered question until more research is completed.

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APPENDICES

APPENDIX A

Consent Forms

The University of Oklahoma
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

PERMISSION FORM

With full knowledge of my students' participation in the study entitled "The Impact of a Teacher Preparation Program on the Epistemological, Pedagogical, and Personal Beliefs of Preservice Elementary Mathematics Teachers", I hereby give permission to Ms. A. Jean Krows, a doctoral student in the Department of Educational Psychology at the University of Oklahoma, to administer a survey questionnaire during my class.

I understand that participation in the study is voluntary and that each student who decides to participate will sign a separate informed consent form. I understand participation will consist of completion of a short information sheet and a five part survey on the student's views about mathematics. I understand that this should take approximately 15-20 minutes and that all responses will be completely confidential. I understand that no names will appear on either the information sheet or the survey form and that the informed consent forms will be kept separate from the other instruments. In addition, I understand that no psychological or physical risk to my students can occur from participation in this study.

____
INSTRUCTOR NAME (please print)

____
SIGNATURE

____
COURSE

____
DATE

820 Van Vleet Oval, Room 321, Norman, Oklahoma 73019-2041 PHONE: (405) 325-5974

The University of Oklahoma
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

INFORMED CONSENT FORM

for research conducted under the auspices of the University of Oklahoma-Norman Campus

You are being asked to participate in a study entitled "The Impact of a Teacher Preparation Program on the Epistemological, Pedagogical, and Personal Beliefs of Preservice Elementary Mathematics Teachers". This study is being conducted by Ms. A. Jean Krows, a doctoral student in the Department of Educational Psychology at the University of Oklahoma. Ms. Krows is under the supervision of Dr. Raymond B. Miller, her doctoral committee chair. The purpose of this study is to examine students' personal attitudes toward mathematics, their views on teaching and learning mathematics, and their views on the nature of the science of mathematics. Further, the study will examine if there is a difference in these views among students at different points in their educational program.

If you decide to participate, you will fill out a short information sheet and a 5 part survey on your views about mathematics. This should take approximately 20 minutes. Your responses will be completely confidential. Your name will not appear on either the information sheet or the survey form. The informed consent forms will be kept separate from the other instruments. This survey is being completed with the permission of your professor.

All information obtained from this project will be reported in terms of group trends, never in terms of individual responses.

Your participation in this project is voluntary, so there is no penalty for not participating. If you decide to participate, we appreciate your time and believe your responses will provide valuable insight to the researcher. You may drop out at any time during the project without penalty. There is no psychological or physical risk to you as a participant.

If you desire any further information about this study or about your participation in this study, please call Jean Krows at 799-5694. If you desire information regarding your right as a research participant you may contact the Office of Research Administration at 325-4757.

If you are willing to participate please read the following paragraph carefully and fill out the indicated blanks. Thank you for your cooperation.

I consent to participate in the project described above. I understand my scores, responses and all other information about me will be kept confidential. I understand I am free to drop out of this project at any time without penalty.

STUDENT NAME (please print)	SIGNATURE	DATE

820 Van Vleet Oval, Room 321, Norman, Oklahoma 73019-2041 PHONE: (405) 325-5974

APPENDIX B

Preservice Teachers' Beliefs Questionnaire and Information Sheet

Directions: Please circle the correct response.

1. Survey: A B

2. Sex M F

3. I am a: A. Full time student B. Part time student

4 Current status:
A. Freshman B. Sophomore C. Junior D. Senior. E. Grad or TE+

5. My age range is:
A. Under 21 B. 21-25 C. 25-30 D. Over 30

6. Area of specialty:
A. Early childhood or elementary education
B. Special education
C. Music
D. Middle school or Secondary mathematics
E. Other secondary
F. Other___________________

7. My current GPA
A. 3.5 or higher B. 2.5 - 3.5 C. below 2.5

8. The highest math course I successfully completed in high school was
A. General math or prealgebra
B. Algebra I
C. Geometry
D. Algebra II
E. Advanced math courses such as Trigonometry, Calculus, etc.

9. I consider myself a
A. good math student
B. average math student
C. Poor math student

10. The ethnic group which best describes me is
A. African American
B. Asian
C. Caucasian
D. Hispanic
E. Native American
F. Other___________________

11. The course in which I am completing this survey is
A. MATH 1473/1503
B. MATH 3213
C. EDMA 3153
D. EDMA 4053
E EIPT 3473
F. EIPT 3483
G. Other___________________

12. (For early childhood or elementary majors only)
I have completed or am near completion of:
A. no mathematics methods courses
B. one mathematics methods course
C. tow mathematics methods courses
D. more than two mathematics methods courses

SURVEY A

FOR THOSE SEEKING CERTIFICATION IN ELEMENTARY EDUCATION

This survey will give a general picture of your views on mathematics. It will ask about your attitudes toward mathematics and your beliefs about learning and teaching mathematics.

Part I--Directions: The following statements represent your personal attitudes toward math. Read each statement and decide to what extent you agree with the statement. Choose 1 if the statement strongly represents your attitude. Choose 5 if the statement does not represent your attitude at all. Or, choose the number in between which best reflects your agreement or disagreement with the item. Record the corresponding number on your answer sheet.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

1. I am looking forward to taking more mathematics courses..1 2 3 4 5

2. I enjoy learning how to use technologies (e.g., calculators, computers, etc.) in mathematics classrooms.......................................,,..1 2 3 4 5

3. I like mathematics....................................1 2 3 4 5

4. I possess the ability to understand and work with mathematics.............................. ...... 1 2 3 4 5

5. I find learning math is very stressful................1 2 3 4 5

Part 2 Directions: The following statements deal with your attitudes about teaching math, your personal feelings of confidence in teaching mathematics, your confidence in teachers in general and your outcome expectations in teaching. Read each statement carefully and decide whether you agree with it. Record the corresponding number on your answer sheet.

6. The idea of teaching mathematics scares me............1 2 3 4 5

7. I think I will prefer teaching mathematics to teaching other subjects............................1 2 3 4 5

8. I am looking forward to taking more mathematics methods courses............................1 2 3 4 5

1 Strongly Disagree	2 Disagree	3 Undecided	4 Agree	5 Strongly Agree

9. I am looking forward to taking more educational psychology courses	1	2	3	4	5
10. I am looking forward to taking more courses in mathematics teaching methods	1	2	3	4	5
11. I would prefer not to have to teach math	1	2	3	4	5
12. I am capable of providing instruction in math based on my students' interests	1	2	3	4	5
13. I am capable of providing math instruction using a variety of hands-on manipulatives	1	2	3	4	5
14. I have the ability to adjust my classroom activities in math to the learning needs of individual students	1	2	3	4	5
15. I am capable of providing appropriate learning experiences in math for diverse learners (e.g., gifted, learning disabled, attention deficit, non-English speaking)	1	2	3	4	5
16. I have the ability to integrate math activities into other curriculum areas	1	2	3	4	5
17. I have the ability to provide students with challenging activities in math	1	2	3	4	5
18. I have the ability to prepare engaging materials to teach math	1	2	3	4	5
19. I have the ability to plan effective lessons in math	1	2	3	4	5
20. I have the ability to apply cooperative group learning strategies in teaching math	1	2	3	4	5
21. I have the ability to provide worked examples during math instruction	1	2	3	4	5
22. I am capable of conducting whole group instruction in math	1	2	3	4	5
23. I am capable of conducting small group instruction in math	1	2	3	4	5

1 Strongly Disagree	2 Disagree	3 Undecided	4 Agree	5 Strongly Agree

24. I am capable of organizing learning activities in math according to students' backgrounds...........1 2 3 4 5

25. I am capable of selecting well-designed computer software to integrate into my math curriculum........1 2 3 4 5

26. I am capable of providing learning activities for students that will allow them to use calculators or other technology to attain an instructional goal in math..........................1 2 3 4 5

27. I am capable of using drill and practice activities to reach instructional goals in math.................1 2 3 4 5

28. I feel prepared to teach mathematics.................1 2 3 4 5

29. I feel prepared to teach mathematics emphasizing conceptual learning..................................1 2 3 4 5

30 I Believe that I will be responsible for my students' achievement in math.........................1 2 3 4 5

31. I think most teachers can positively affect student achievement in math...........................1 2 3 4 5

32. I believe teachers have control over their students' achievement in math.........................1 2 3 4 5

Part 3--Directions: The following statements deal with your expectations with regard to the act of teaching math and teacher training in math. Read each statement carefully and decide whether you agree with it. Record the corresponding number on your answer sheet.

33. Teaching math will be stressful......................1 2 3 4 5

34. I am looking forward to teaching math................1 2 3 4 5

35. Compared to other subjects I will teach, I expect to put more effort into working with students who are having trouble grasping a new math concept or procedure than students in other subjects...........1 2 3 4 5

36. Compared to other subjects I will teach, I expect to put more effort into developing engaging math activities than other subjects......................1 2 3 4 5

1 Strongly Disagree	2 Disagree	3 Undecided	4 Agree	5 Strongly Agree

37. Compared to the effort I expect to exert in planning for other subject areas, I expect to put more effort into planning daily math instruction................1 2 3 4 5

38. I expect to follow the textbook closely when teaching mathematics................................1 2 3 4 5

39. I expect to have to try a variety of instructional strategies until I find a strategy that is effective with my students in math............................1 2 3 4 5

40 I expect to have to try a variety of approaches to teaching math in order to discover strategies that will motivate my students to improve their understanding of math................................1 2 3 4 5

41. I expect to spend a lot of time and effort in developing instructional activities to supplement the mathematics textbook..............................1 2 3 4 5

42. I expect that the college mathematics courses I take will be helpful to me in teaching mathematics....1 2 3 4 5

43. I expect that the college educational psychology courses I take will be helpful to me in teaching mathematics.................................1 2 3 4 5

44. I expect that the mathematics methods courses I take will be helpful to me in teaching math.........1 2 3 4 5

45. I want to learn how to use technologies (e.g. calculators, computers, etc.) to teach math...........1 2 3 4 5

Part 4--Directions: The following statements deal with your views about how mathematics should be taught. Read each statement carefully and decide whether you agree with it. Record the corresponding number on your answer sheet.

46. Students should understand the meaning of a procedure (i.e., two-digit addition, multiplication) before they memorize the rules on how to do them.............................1 2 3 4 5

47. Time should be spent developing conceptual understanding before students spend much time practicing computational procedures..................1 2 3 4 5

1 Strongly Disagree	2 Disagree	3 Undecided	4 Agree	5 Strongly Agree

48. Even students who have not learned algorithms can have effective methods for solving problems......1 2 3 4 5

49. The teacher should demonstrate how to solve math problems before students are allowed to try solving problems on their own.........................1 2 3 4 5

50. An effective teacher demonstrates the right way to do a math problem.............................1 2 3 4 5

51. Students should have many informal experiences solving word problems before they are expected to memorize formulas and algorithms...................1 2 3 4 5

52. Most students have to be shown how to solve math problems the right way..........................1 2 3 4 5

53. Students will not understand an arithmetic procedure (i.e., two-column addition) until they have memorized some of the basic number facts........1 2 3 4 5

54. Students should be allowed to invent ways to solve arithmetic problems before the teacher demonstrates how to solve them.......................1 2 3 4 5

55. Time should be spent practicing computational procedures before students are expected to understand the concept behind the procedures........1 2 3 4 5

56. The goals of instruction in mathematics are best achieved when students find their own methods for solving problems.................................1 2 3 4 5

57. Allowing students to discuss their thinking helps them to make sense of mathematics...................1 2 3 4 5

58. Students can figure out ways to solve many kinds of arithmetic problems without formal instruction...1 2 3 4 5

59. When a student is having difficulty solving an arithmetic problem, the teacher should tell the student how to solve the problem...................1 2 3 4 5

1 Strongly Disagree	2 Disagree	3 Undecided	4 Agree	5 Strongly Agree

60. A teacher should allow a student who is having difficulty solving an arithmetic problem to continue to try to find a solution on his/her own..1 2 3 4 5

61. Frequent pencil and paper practice with arithmetic problems is essential in order for students to learn them..1 2 3 4 5

62. Students' explanations of their solutions to arithmetic problems are good indicators of their mathematics learning..............................1 2 3 4 5

63. Time should be spent practicing basic computational skills before students spend much time working with manipulatives.................................1 2 3 4 5

64. Students need explicit instructions on how to solve most mathematics problems..................1 2 3 4 5

65. Students learn mathematics best from teachers' well designed demonstrations and explanations.......1 2 3 4 5

66. Students should have opportunities to experience manipulating materials in the mathematics classroom before teachers introduce mathematics riles and vocabulary................................1 2 3 4 5

67. Students should be given regular opportunities to think about what they have learned in the mathematics classroom................................1 2 3 4 5

68. Using technologies (e.g., calculators, computers, etc.) in mathematics lessons will improve students" understanding of mathematics.........................1 2 3 4 5

69. Small group activity should be a regular part of the mathematics classroom................................1 2 3 4 5

70. Calculators should not be available for students when they are learning the basic skills in mathematics...1 2 3 4 5

Part 5--Directions: The following statements deal with your epistemological beliefs about the nature of mathematics. Read each statement carefully and decide whether you agree with it. Record the corresponding number on your answer sheet.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

71. Mathematics consists of unrelated topics (e.g., algebra, arithmetic, calculus and geometry)..1 2 3 4 5

72. Getting the correct answer to a problem in the mathematics classroom is more important than investigating the problem in a mathematical manner..................................1 2 3 4 5

73. The primary reason for learning mathematics is to learn skills for everyday life..................1 2 3 4 5

74. Mathematics is a constantly expanding field...........1 2 3 4 5

75. Practices and procedures in mathematics are rarely replaced by new or different practices........1 2 3 4 5

76. The use of technologies (e. g,. calculators, computers, etc.) in mathematics is an aid primarily for slow learners..........................1 2 3 4 5

77. I think I will prefer teaching mathematics by emphasizing connections among disciplines..........1 2 3 4 5

78. Mathematics should be presented to students in such a way that they can discover relationships for themselves........................1 2 3 4 5

79. Students usually can create ways to solve math problems by themselves...............................1 2 3 4 5

80. Mathematics techniques can be created as a need for it arises in the course of solving a real life problem..1 2 3 4 5

81. Given appropriate materials, students can create meaningful procedures for computation.............. 1 2 3 4 5

82. Mathematics is a set of exact procedures for solving problems..................................1 2 3 4 5

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

83. I believe truly understanding mathematics requires special abilities that only some some students possess................................1 2 3 4 5

APPENDIX C

Criteria for Categorization of Teachers' Mathematical Beliefs and Practices

Tables 4 to 7

Table 4

Criteria for the Categorization of Teachers Beliefs

About the Nature of Mathematics[1]

Traditional
- Mathematics is an unrelated collection of facts, rules, and skills.
- Mathematics is fixed, predictable, absolute, certain, and applicable.

Primarily traditional
- Mathematics is primarily an unrelated collection of facts, rules, and skills.
- Mathematics is primarily fixed, predictable, absolute, certain, and applicable.

Even mix of traditional and nontraditional
- Mathematics is a static but unified body of knowledge with interconnecting structures.
- Mathematics is equally both fixed and dynamic, both predictable and surprising, both absolute and relative, both doubtful and certain, and both applicable and aesthetic.

Primarily nontraditional
- Mathematics is primarily a static but unified body of knowledge.
- Mathematics involves problem solving.
- Mathematics is primarily surprising, relative, doubtful, and aesthetic.

Nontraditional
- Mathematics is dynamic, problem driven, and continually expanding.
- Mathematics can be surprising, relative, doubtful, and aesthetic.

[1] All tables in this section are adapted from Raymond, A. M. (1997), Inconsistency between a beginning elementary school teacher's mathematics beliefs and teaching practices. Journal for Research in Mathematics Education, 28(, 550-576.

Table 5

Criteria for the Categorization of Teachers

Beliefs About Learning Mathematics

Traditional

- Students passively receive knowledge from the teacher.
- Students learn mathematics by working individually.
- Students engage in repeated practice for mastery of skills.
- There is only one way to learn mathematics.
- Memorization and mastery of algorithms signify learning.
- Student learns mathematics solely from the textbook and worksheets.
- Many students are just not able to learn mathematics.
- Students' learning of mathematics depends solely on the teacher

Primarily traditional

- Students primarily engage in practice for mastery of skills.
- Memorization and mastery of algorithms provide primary evidence of learning
- The teacher is more responsible for learning than the student.
- Mathematics is learned primarily from the textbook and worksheets.
- Students work individually except perhaps to work on homework.
- Students are primarily passive learners, raising questions on occasion.

Even mix of traditional and nontraditional

- Students should learn mathematics through both problem solving and textbook work.
- Students should both understand and master skills and algorithms.
- Students should do equal amounts of individual and group work.
- There is more than one way to learn mathematics.
- Most students can learn mathematics.
- Learning mathematics is equally the responsibility of students and teachers.
- Trying hard is as likely to aid mathematics learning as is being naturally good.
- Repeated practice is as likely to help in the learning of mathematics as is having insights as a result of explorations.

Primarily nontraditional

- Students primarily learn mathematics through problem-solving tasks.
- Students primarily learn mathematics from working with other students.
- Learning is evidenced more through ability to explain understanding than through expert memorization and performance of algorithms .
- Students are more responsible for their own learning than the teacher.
- Students learn mathematics primarily as active learners.

Nontraditional

- The students role is that of autonomous explorer.
- Students learn mathematics only through problem-solving activities.
- Students learn mathematics without textbook or paper-and-pencil activities.
- Students learn mathematics through cooperative group interactions.
- Students are active mathematics learners.
- All students can learn mathematics.
- Each student learns mathematics in his or her own way.

Table 6

Criteria for the Categorization of Teachers' Beliefs About Teaching Mathematics

Traditional
- The teacher's role is to lecture and to dispense mathematical knowledge.
- The teacher's role is to assign individual seatwork.
- The teacher seeks "right answers" and is not concerned with explanations.
- The teacher approaches mathematical topics individually, a day at a time.
- The teacher emphasizes mastery and memorization of skills and facts.
- The teacher instructs solely from the textbook.
- Lessons are planned and implemented explicitly without deviation.
- The teacher assesses students solely through standard quizzes and exams.
- Lessons and activities follow the same pattern daily.

Primarily traditional
- The teacher primarily dispenses knowledge.
- The teacher primarily values right answers over process.
- The teacher emphasizes memorization over understanding.
- The teacher primarily (but not exclusively) teaches from the textbook.
- The teacher includes a limited number of opportunities for problem solving.

Even mix of traditional and nontraditional
- The teacher includes a variety of mathematical tasks in lessons.
- The teacher equally values product and process.
- The teacher equally emphasizes memorization and understanding.
- The teacher spends equal time as a dispenser of knowledge and as a facilitator.
- Lesson plans are followed explicitly at times and flexibly at others.
- The teacher has students work in groups and individually in equal amounts.
- The teacher uses textbook and problem-solving activities equally.
- The teacher helps students both enjoy mathematics and see it as useful.

Primarily nontraditional
- The teacher primarily facilitates and guides, with little lecturing.
- The teacher values process somewhat more than product.
- The teachers emphasizes understanding over memorization.
- The teacher makes problem solving an integral part of class.
- The teacher uses the textbook in a limited way.

Nontraditional
- The teacher s role is to guide learning and pose challenging questions.
- The teacher's role is to promote knowledge sharing
- The teacher.r clearly values process over product.
- The teacher does not follow the textbook when teaching.
- The teacher provides only problem- solving, manipulative driven activities.
- The teacher does not plan explicit, inflexible lessons.
- The teacher has students work in cooperative groups at all times.
- The teacher promotes students' autonomy.
- The teacher helps students to like and value mathematics.

Table 7:

Criteria for the Categorization of Teachers' Mathematics Teaching Practice

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Traditional

- The teacher instructs solely from the textbook.
- The teacher follows lesson plans rigidly.
- The teacher approaches mathematics topics in isolation.
- The teacher approaches mathematics instruction in the same pattern daily.
- The teacher has students engage only in individual paper-and-pencil tasks.
- The teacher creates an environment in which students are passive learners.
- The teacher poses questions in search of specific, predetermined responses.
- The teacher allows no student-to-student interactions.
- The teacher evaluates students solely via exams seeking "right answers.

Primarily Traditional

- The teacher instructs primarily from the textbook with occasional diversions from the text
- The teacher creates an environment in which students are passive learners, occasionally calling on them to play a more active role.
- The teacher primarily evaluates students through standard quizzes and exams, only occasionally using other means.
- The teacher primarily encourages teacher-directed discourse, only occasionally allowing for student- directed interactions.

Even Mix of Traditional/Nontraditional

- The teacher teaches equally from textbook and problem-solving activities.
- The teacher creates a learning environment that at times allows students to be passive learners and at times active explorers
- The teacher evaluates students' learning equally through standard quizzes and exams and alternative means, such as observations and writing.
- The teacher encourages teacher-directed and student-directed discourse.

Primarily Nontraditional

- The teacher primarily engages students in problem- solving tasks.
- The teacher primarily presents an environment in which students are to be active learners, occasionally having them play a more passive role.
- The teacher primarily evaluates students using means beyond standard exams.
- The teacher encourages mostly student-directed discourse.

Nontraditional

- The teacher solely provides problem-solving tasks
- The teacher selects tasks based on students' interests and experiences.
- The teacher selects tasks that stimulate students to make connections.
- The teacher selects tasks that promote communication about mathematics.
- The teacher creates an environment that reflects respect for students' ideas and structures the time necessary to grapple with ideas and problems.
- The teacher poses questions that engage and challenge students' thinking.
- The teacher has students clarify and justify their ideas orally and in writing.
- The teacher has students work cooperatively, encouraging communication.
- The teacher observes and listens to students to assess learning.

APPENDIX D

THE PILOT STUDY

An Exploration of the Differences in Attitudes and Beliefs about Mathematics in Preservice Elementary Education Teachers

A Pilot Study

A. Jean Krows

Purpose of the Study

This study was undertaken to establish preliminary reliability of an instrument designed to measure preservice elementary education teachers' attitudes, personal, epistemological, and pedagogical beliefs about mathematics. A second focus of the study was to compare two groups of students who differed in their amount of teacher training to determine if differences exist on these variables.

Research Questions

What are the beliefs held by preservice elementary teachers about what is effective mathematics teaching (pedagogy)?

What are the beliefs held by preservice teachers about the nature of mathematics (epistemology)?

What are the attitudes preservice teachers hold toward mathematics?

Do students differ from one another on these beliefs as a function of educational level?

Methodology

Design

This study was a quasi-experimental design, using a purposive sample.

Procedure

In the fall semester of 1998, 103 preservice elementary education teachers at a large suburban university in the Southwest were administered a questionnaire. The survey was administered during a class period after obtaining permission from the course instructors and from the participants.

Sample

One hundred three students from six sections enrolled in either a professional education or mathematics methods course participated. Forty three students who had completed, at most, one mathematics methods course were clustered into the first group (Early Ed). The second group (Mid-Ed (F)) consisted of students who had completed two of the three required mathematics methods courses and both of the required professional education courses. Twenty-nine students fell into the third group with a mixture of educational backgrounds. These students were not used in the final data analysis.
They were used in the overall internal reliability test.

Instrument

-Students were administered an 83-item Likert scale questionnaire. Choices were selected from: 1=strongly agree, 2=agree, 3=undecided, 4=disagree, or 5=strongly disagree.
-Items were coded exactly as answered on the questionnaire.
-Certain items were reverse coded to bring parallel, but oppositely worded statements into equal value.
-Not all items from the questionnaire were used. Only a few items were selected to get a preliminary idea of the relationships.

Results

-Cronbach's alpha overall internal reliability was .90
-A comparison of the Early Ed group to the Mid-Ed (F) group was analyzed using a two-tailed significance probability.
-Attitude yielded a statistically significant difference ($T(82) = 2.39$, $p = .02$).
-Epistemology yielded a statistically significant difference ($T(82) = 2.12$, $p = .04$).
-Pedagogy yielded a statistically significant difference ($T(82) = 5.99$, $p = .0001$).

Table 1

Group comparison
on Item 3: "I like mathematics".

	N	Mean	tandard De	T	Sig
Early Ed	43	2.95	10.8	2.34	0.02
Mid-Ed (F)	41	3.51	1.07		

Table 2

Epistemology

	N	Mean	tandard De	T	Sig
Early Ed	43	3.87	0.7	2.12	0.04
Mid-Ed (F)	41	3.42	0.81		

Table 3

Pedagogy

	N	Mean	tandard De	T	Sig
Early Ed	43	3.61	,46	5.99	0.0001
Mid-Ed (F)	41	4.17	0.41		

Conclusion

Based on the statistical tests, students who had completed two mathematics methods courses had significantly more positive attitudes toward mathematics than students who had not yet taken a mathematics methods course. They also displayed a more constructivist orientation in pedagogical beliefs and showed a more sophisticated epistemological view on the nature of mathematics.

APPENDIX F

Correlational Matrices for the Pre-Ed, Early Ed, Mid-Ed (F), Mid-Ed (S), and Full Ed Groups

Tables 8 to 12

Table 8

Correlational Matrix For

Pre-Teacher Education Group

	ATTIT	EFF	PREP	OETCN	EFFO	TPRP	TRAD	CONS	EPIS
ATTIT	1.00								
EFF	0.19	1.00							
PREP	0.28	.62**	1.00						
OETCN	0.16	.45**	0.29	1.00					
EFFO	0.21	.32*	0.29	-0.13	1.00				
TPRP	-0.02	-0.05	-0.15	0.17	-0.22	1.00			
TRAD	0.22	0.08	0.14	-0.24	.60**	-0.14	1.00		
CONS	0.10	.42**	.30*	0.25	0.17	0.09	0.23	1.00	
EPIS	0.26	.37*	.49**	0.07	.31*	0.04	.43**	.52**	1.00

n of cases = 46   2-tailed significance   * p=.01   ** p=.001

Table 9

Correlational Matrix For

Early Teacher Education Group

	ATTIT	EFF	PREP	OETCN	EFFO	TPRP	TRAD	CONS	EPIS
ATTIT	1.00								
EFF	0.18	1.00							
PREP	0.22	.49**	1.00						
OETCN	0.11	.43**	0.15	1.00					
EFFO	0.22	0.03	-0.11	-0.05	1.00				
TPRP	0.03	0.28	0.22	.31*	-0.06	1.00			
TRAD	.32*	0.12	0.16	0.20	0.14	-0.07	1.00		
CONS	0.18	.44**	.42**	.55**	-0.06	0.27	.38*	1.00	
EPIS	0.20	.32*	0.17	.50**	-0.01	0.27	.45**	.74**	1.00

n of cases = 43   2-tailed significance   * p=.01   ** p=.001

Table 10

Correlational Matrix For

Spring Mid Level Teacher Education Group

	ATTIT	EFF	PREP	OETCN	EFFO	TPRP	TRAD	CONS	EPIS
ATTIT	1.00								
EFF	0.31	1.00							
PREP	.331*	.569**	1.00						
OETCN	0.07	0.15	9 .59	1.00					
EFFO	-0.17	0.09	72 .3	-0.26	1.00				
TPRP	.492**	.403*	01 5	-0.06	-0.23	1.00			
TRAD	0.10	0.22	56 .3	0.12	0.32	-0.14	1.00		
CONS	0.21	0.41	08 .5	0.23	-0.07	0.23	431**	1.00	
EPIS	0.23	.343*	56 .7	.404*	0.17	-0.10	524**	610**	1.00

n of cases = 39 2-tailed significance * p=.01 ** p=.001

Table 11

Correlational Matrix For

Fall Mid Level Teacher Education Group

	ATTIT	EFF	PREP	OETCN	EFFO	TPRP	TRAD	CONS	EPIS
ATTIT	1.00								
EFF	.34*	1.00							
PREP	.49**	.37*	1.00						
OETCN	0.09	0.28	0.01	1.00					
EFFO	0.29	0.26	.37*	0.40*	1.00				
TPRP	0.29	0.11	.32*	-0.11	0.14	1.00			
TRAD	0.19	0.20	.37*	-0.09	.65**	0.28	1.00		
CONS	0.27	0.25	.51**	0.10	.37*	.39*	.68**	1.00	
EPIS	0.29	0.28	.52**	-0.08	.59**	0.29	0.29	.81**	1.00

n of cases = 43 2-tailed significance * p=.01 ** p=.001

Table 12

Correlational Matrix For

Full Teacher Education Group

	ATTIT	EFF	PREP	OETCN	EFFO	TPRP	TRAD	CONS	EPIS
ATTIT	1.00								
EFF	0.31	1.00							
PREP	.54**	.57**	1.00						
OETCN	0.01	0.23	0.14	1.00					
EFFO	0.02	0.17	.17\	-0.27	1.00				
TPRP	.37*	0.24	.59**	0.10	0.00	1.00			
TRAD	0.24	.42**	.42**	-0.03	.52**	0.20	1.00		
CONS	0.11	.54**	.31*	0.21	0.18	0.05	.62**	1.00	
EPIS	0.31	.55**	.46**	0.13	0.25	0.27	.65**	.81**	1.00

n of cases = 41 2-tailed significance * p=.01 ** p=.001

Note. ATTIT = Attitude toward mathematics; EFF = self-efficacy about learning to teach mathematics; PREP = feeling prepared to teach mathematics; OETCN = outcome expectations for teach control of student outcomes; EFFO = expectations for effort in teaching mathematics; TPRP = expectations for adequacy of teacher preparation program; TRAD = traditionalist pedagogy views; CONS constructivist pedagogy views; EPIS = epistemological views about the nature of mathematics and learning.