TEACHERS' BELIEFS ABOUT MATHEMATICS AND THE TEACHING OF MATHEMATICS AS THEY ENTER THE TEACHING PROFESSION

by

JANET M. SHIVER

(Under the Direction of Denise S. Mewborn)

ABSTRACT

Not surprisingly, new teachers are faced with many expected and unexpected constraints and challenges in their first year of teaching. Using both survey and interview data, the progressive beliefs of five new elementary teachers were explored as they entered their first year of teaching. This paper examines the stability of the beliefs about both the nature of mathematics and the teaching of mathematics held by these young teachers.

Keith Leatham's (2006) Sensible Systems framework influenced both the methodology used to collect data for this study as well as the analysis of the data. His framework suggests that teachers are complex, rational individuals who are unable to act counter to what they believe. By employing this framework, I was able to avoid some of the common pitfalls associated with beliefs research. Instead of accepting as true and then focusing on the inconsistencies between teachers' actions and their stated beliefs, I was able to look more deeply at the beliefs themselves and what other, perhaps non mathematical, beliefs might be causing the perceived inconsistency.

The results of this study were somewhat surprising. Instead of the fragile belief systems suggested by many previous research studies, these progressive teachers appeared to have relatively stable belief systems even when faced with the daily challenges and constraints of the classroom. These challenges, the effect they had on the teacher's beliefs and the teachers' methods for dealing with them were identified and discussed.

INDEX WORDS: mathematical beliefs, elementary education, mathematics education, preservice teachers

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DEDICATION

I dedicate this doctoral dissertation to the people who inspire me daily…

to Todd for all of his support and love

to Andrew for his patience and voice of reason

to Justin for his constant encouragement

to Morgan for her daily words of inspiration.

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CHAPTER 1

Introduction

The teaching of mathematics is a complex and ever changing process that involves continually making decisions. With recent reform efforts (NCTM, 2000) encouraging teachers to provide quality instruction in which students construct their own understandings, mathematics teachers have been challenged to provide the richest learning environment possible for by engaging students in meaningful and useful mathematics. They have been asked to know how to actively involve students in the mathematics so that the students can increase their conceptual understanding and increase their ability to problem solve. They are required to evaluate multiple solutions to problems and to promote varying strategies among their students. Additionally, they are expected to know when and how to embrace students' questions as an opportunity to explore new ideas and when to postpone the discussion. In other words, teachers are continually asked to make important decisions about the mathematics they are teaching and the methods they are using to teach the mathematics.

Mathematics teacher educators have begun to search for new ways to embrace these reform efforts and to improve mathematics instruction. In this search to improve instruction, mathematics educators have begun to realize the importance of better understanding teacher's beliefs about mathematics and the teaching of mathematics and its apparent relationship to their teaching practices. As one of these mathematics educators, I have always been interested in what guides the decisions we make regarding the mathematics we teach. Why will one teacher vigorously claim that mathematics is a human invention while another will vehemently argue that all mathematics is discovered? What is it that causes us to approach mathematics and the teaching of mathematics differently from others? How can one mathematical idea evoke so many varying conceptual understandings in people? These questions are what drive me to investigate the role that beliefs play in this daily decision-making process.

Some of the most recent reform efforts in mathematics education have strongly encouraged researchers to look into not only the beliefs of teachers but also the connection between teachers' beliefs and their instructional practice. In response to this plea, there have been many attempts by researchers to find new and better ways to investigate these relationships. Research in the field of beliefs is very broad and focuses on a wide range of ideas. Topics such as teacher beliefs, the relationship between beliefs and practice, the interaction between teacher beliefs and student learning and achievement, changing teacher beliefs, and the relationship between beliefs and teacher learning, are all covered under the broad umbrella that is beliefs. I have found all of these areas to be fascinating but I am most interested in examining how the beliefs of teachers withstand the challenges and constraints of the classroom.

Some research in the area of beliefs suggests that teachers make daily decisions about the mathematics they are teaching arbitrarily with little consideration to what they believe about the best way to teach a concept (Raymond, 1997). Other research goes even farther to suggest that teachers will actually choose to teach mathematics in direct conflict with the beliefs they hold about mathematics and the teaching of mathematics (Cohen, 1990). Cohen (1990) suggested that a teacher's ignorance of the mathematics she teaches prevents her from teaching in the manner in which she believes is best. He felt that teachers could verbalize the best ways to teach mathematics but their lack of background in complex mathematics prevented them from acting in the way they professed. Additional research has found a dramatic shift in beliefs of first-year teachers from the more progressive beliefs that they developed during their college experiences to more traditional views taken on during their teaching experiences (Zeichner, 1981). Having been a classroom teacher, I found it difficult to accept that any teacher would make decisions in direct conflict with the beliefs that she holds. I also found it difficult to accept that an established belief could so easily shift to an opposing view in such a short period of time. For these reasons, I was interested in determining the beliefs that preservice teachers have after being exposed to the ideas presented during their mathematics education courses and how these beliefs hold up after they leave the university setting and enter their first year of teaching.

Background

Current research shows that teachers' beliefs toward mathematics strongly affect their future teaching practices (Ambrose, 2004). Deborah Ball (1988) suggested that "teachers' understandings and beliefs about mathematics interact with their ideas about the teaching and learning of mathematics and their ideas about pupils, teachers and the context of classrooms" (p.19). Thus it appears that the beliefs of preservice teachers will not only affect how they make sense of mathematics but will also affect the students that they teach.

So, with this in mind, it was my desire to conduct a study that focused on preservice elementary school teachers from a small public liberal arts college in central

Georgia where I teach. I wanted to determine the beliefs held by these preservice teachers regarding mathematics and the teaching of mathematics after each of them completed a sequence of three carefully designed mathematics education courses at the university. I then wanted to follow these preservice teachers into their first year of teaching to determine whether or not their beliefs stayed consistent with those the held in college or if changes occurred. In addition, it was my hope that I would be able to determine what factors had the greatest impact on their beliefs.

First year teachers are constantly faced with uncertain situations to evaluate and make sense of. In making sense of these situations, they are constantly faced with the powerful influence of the school's social context. Within the school setting, teachers are forced to deal with not only their own expectations, but also those from students, parents, fellow teachers, and administrators (Ernest, 1988). In addition, they must deal with an imposed institutionalized curriculum, the school adopted text, the imposed method of assessment, and state or national guidelines for teaching mathematics (Ernest, 1988). These powerful external sources force teachers to internalize a heavy set of imposed constraints that in turn are likely to affect the way in which they operate within their classrooms. To make sense of this complex environment teachers turn to the belief systems that they developed in college and throughout their lives.

Beliefs serve to filter out the complexity of a situation, to make it comprehensible, and compel teachers to act in a particular ways (Ambrose, 2004). But which beliefs cause us to act? Is it our beliefs about how students best learn mathematics that take precedence or is it our more general beliefs about learning? While there is no easy answer to this question, one point that beliefs researchers appear to agree upon is that if we want to fully understand the academic behavior of teachers within the mathematics classroom it is important that we begin to understand the beliefs they hold about teaching and their classroom practice (O'pt Eynde, 2003). Because of their lack of experience in dealing with the complexities of the teaching environment, first year teachers' beliefs appear to be the most vulnerable to outside influences. It is, therefore, extremely important that we begin to understand how their beliefs are affected and what has the greatest impact on them.

A few studies have tried to directly address the impact of the constraints and contingencies of the school context and their effect on the beliefs and actions of first year teachers; one such study was done by Ensor (2001). After studying a group of first year secondary mathematics teachers in South Africa, she found that they often recontextualized their beliefs from their mathematics methods courses into their first year of teaching. The results of her study showed that these preservice teachers were able to speak in a professional manner about mathematics and mathematics teaching, but their classroom practices showed little evidence of reflecting these beliefs (Ensor, 2001). Her study showed that her former students, now first year teachers, continued to discuss sound pedagogical ideas for teaching mathematics, but these ideas were not effectively incorporated into the classroom. While Ensor's (2001) main focus, like so many other researchers, was on the mismatch between the teachers' stated beliefs and their classroom practice, I would argue that this mismatch may or may not indicate any real change in the beliefs held by these practicing teachers. Researchers (e.g. Leatham, Speer,& Mewborn, 2006) have pointed out that these observed mismatches between beliefs and practices may just be a failure on the part of the researcher to correctly interpret what it is that he is observing and not an actual disconnect. These researchers suggest that teachers should be regarded as rational human beings and therefore stress that there must be underlying reasons for their actions; perhaps other beliefs that are more centrally held are controlling teachers' actions and not their beliefs about mathematics.

A second study that directly investigated the impact of the pressures on first year teachers was done by MacNab (2003). He began his study by pointing out that the combination of beliefs, social context, and level of consciousness in relating these beliefs to practice underlies the complexity involved in the effective teaching of mathematics. McNab(2003) offered one explanation for the often observed disconnect between beliefs and practice. He suggested that first year teachers often struggle to integrate their beliefs about mathematics and the teaching of mathematics with classroom practice. First year teachers appear to struggle with how to effectively put into practice their beliefs about mathematics and teaching mathematics while being faced with the constraints of the classroom. McNab (2003) pointed out that the cultural and ideological beliefs of teachers and their interactions with the professional practice of teaching mathematics can come from many sources, including the teachers' own experiences learning mathematics, their likes and dislikes about mathematics, their degree of mathematical understanding, official curricular guidance, their views of how mathematics is best learned, and their views about teacher-pupil relationships. Again we see the importance of understanding the beliefs teachers hold about mathematics and the teaching of mathematics, studying the interactions these beliefs have with other more general beliefs about teaching and learning, and establishing a method to evaluate the strength of these beliefs once these teachers enter the real world of teaching.

While many beliefs studies have focused directly on both the implicit and explicit beliefs held by teachers about mathematics and the teaching of mathematics, some studies have suggested that in order to understand the complexity of the beliefs held by teachers and their relationship to instructional practice we must broaden our focus to include teachers' more general beliefs about teaching that are not specific to mathematics (Thompson, 1984). Much of the research that currently exists assumes that beliefs about mathematics and the teaching of mathematics are the most central beliefs held when determining the way in which to act within a mathematics classroom. This assumption, that mathematical beliefs will always take precedence over other more general beliefs about teaching and learning, has produced volumes of work describing the mismatch between teachers' practices and their espoused beliefs (e.g., Cohen, 1990). More recently researchers (e.g., Leatham, 2006) have begun to question this assumption. I adopted Leatham's (2006) perspective that teachers are sensible rather than irrational beings who act in direct conflict with their beliefs, in order to investigate whether or not the pressures and constraints of first year teaching change teachers' beliefs about mathematics and the teaching of mathematics. This perspective also allowed me to look for better explanations about apparent conflicts in practice and beliefs.

Research Questions

In this study I examined the beliefs held by preservice elementary school teachers regarding the nature of mathematics and mathematics teaching as they entered the classroom and became first year teachers. The study was designed to determine whether or not changes in their beliefs occurred as these preservice teachers entered their first year of teaching. While pursuing this research, I hoped to answer three questions: (a) What beliefs about mathematics content and pedagogy did first year teachers have prior to entering the classroom? (b) Did the beliefs of these beginning elementary school teachers change when faced with the challenges and realities of the classroom? and (c) What were the greatest challenges to their beliefs about mathematics, and did these factors promote a change in their beliefs?

Rationale

Teachers' beliefs about mathematics and the teaching of mathematics have been studied extensively and much of this existing research has influenced this study. However, my reasons for conducting this research on the resilience of new teacher's beliefs came, not from the current body of published research, but from the lack of beliefs research that extends into the first year of teaching. Many published studies on beliefs focus on teachers' beliefs and how these beliefs are changed (Hart, 2002); however, these studies are usually conducted in an unnatural or contrived setting and not within the teacher's own classroom. In addition, many of the studies are carefully designed to encourage a change in beliefs. Few beliefs studies have been done within an actual teacher's mathematics classroom. Because of this, little research appears to address the trials of daily teaching and how these trials directly affect the mathematical beliefs held by new teachers. This relationship between beginning elementary teachers' beliefs and how the external factors encountered in the first year of teaching influence the development and changing of those beliefs is underrepresented in current beliefs research. While it has been suggested by some researchers (e.g., Cooney, 1998) that social teaching norms and the immediate school environment can have a great influence on the development of beliefs especially in beginning teachers who are particularly susceptible to outside influences, I found few studies that directly or, for that matter indirectly, investigated this connection.

A second concern I had is that most of the studies in this area operate under the assumption that a person's beliefs about mathematics will take precedence over all other beliefs. There are few if any studies that consider the effect of a teacher's more general beliefs about teaching and learning on her choices within the mathematics classroom. When a contradiction between a teacher's stated beliefs and actions is noted, many researchers quickly assume that there is an irrational disconnect between a teacher's beliefs and actions instead of considering alternative explanations such as other, non-mathematical, beliefs taking precedence. By assuming that teachers are rational beings whose actions can be explained within the context of their belief system, I set out to investigate beginning elementary teachers' beliefs and how the experiences of first year teaching affect the formation and changing of their beliefs about mathematics and the teaching of mathematics.

In addition, I wondered if the beliefs that were formed or changed during the preservice teachers' college experience would be lasting. Pajares (1992) explained that the earlier beliefs are incorporated into a teacher's belief structure, the more difficult they are to change, implying that beliefs formed more recently are more susceptible to the influences of first year teaching and more likely to be changed. So how would these newly acquired progressive beliefs that were formed in teacher education courses hold up when faced with the realities of the classroom? Would teachers cling to their new beliefs about mathematics and the teaching of mathematics or would they revert back to their longer established, often more traditional beliefs? With little mathematics education research that investigates these questions, I set out to identify and explore the extent to which various influences on first year elementary teachers affect their beliefs about mathematics and the teaching of mathematics.

In summary, there were three major reasons for my desire to explore this area of research. They were a) research focusing on first year teacher's formation of beliefs as they struggle to develop their teaching practice is rare; b) beginning teachers' beliefs are likely to be challenged in their first year of teaching as their recently developed beliefs about mathematics and pedagogy are pitted against the realities of the classroom; and c) beliefs research often focuses only on the influences that mathematical beliefs have on decision making and does not consider the influences of beliefs held outside this context. I thought that these ideas were important in the study of beliefs and that they were worthy of being pursued. It was important to determine how resilient both the long established and newly formed beliefs of preservice teachers would be when introduced to the classroom culture and pressures of being a first year teacher.

As a result of investigating how teacher beliefs are affected during the first year of teaching, I also hoped to determine what external influences had the greatest impact on these beliefs. It is important for all who are involved with the preparation of future teachers, as well as those who are responsible for the support of current teachers, to understand what external factors influence the beliefs of first year teachers and to what extent these influences change those beliefs. By increasing our understanding of the impact these external influences have on new teachers, teacher educators and school administrators will be better able to help minimize those influences that have caused unwanted changes, enhance those that have caused positive changes, and support those that sustain beliefs consistent with our current understanding of best practices.

I would also like to point out that, while I believe there exists a strong connection between the beliefs a teacher holds and her teaching practice, my primary interest was not in trying to find evidence to show that a connection exists, nor was it in trying to show how beliefs affect student achievement. Instead, I focused my investigation solely on the influence that external factors and other more general pedagogical beliefs have on the beliefs teachers hold about mathematics and the teaching of mathematics.

Research about the beliefs held by preservice teachers in regard to mathematics and mathematics teaching is an important area of research. Many researchers have investigated the beliefs of both elementary and secondary teachers but much of this research has been conducted in very controlled environments and not in the natural setting of the classroom. The research that does exist in this area generally investigates the beliefs of practicing teachers in highly structured situations and not within their classrooms. Because of the important role that beliefs play in the teaching and learning of mathematics, it is of great importance that we continue the investigation into how beliefs are changed and what contributes to a change in beliefs. This current lack of research on the pressures of first year teaching and how they affect the beliefs held by teachers needs to be filled. It was my hope that by conducting this study, I would be able to help begin filling this gap.

CHAPTER 2

Literature Review

In an effort to improve the practice of teaching mathematics and to move toward the adoption of a problem solving approach, mathematics educators are searching to unravel the complex web that defines mathematics teaching. Historically, mathematics educators, as well as others, have tried to implement change at state and national levels, that is, by recommending the adoption of sweeping changes in mathematics curricula. Others have looked at implementing change on a more personal level by increasing the content knowledge of practicing teachers, which in turn was hoped to improve classroom instruction. No one will argue that a well-defined curriculum and teachers with a solid understanding of the subject matter they are teaching is not necessary; however, it can easily be argued that these are not enough to successfully reform mathematics teaching. As is suggested by Ernest (1988), teaching reforms must occur at a much deeper level than just improving the curriculum or the content knowledge of teachers, and real reform cannot take place unless teachers' beliefs about mathematics and the teaching of mathematics are changed. Teachers must believe that the reform efforts currently in place will not only improve classroom instruction but ultimately student learning. If unconvinced, teachers will continue to cling to their more traditional beliefs and reform efforts will be stalled. In fact, it has been shown that the traditional beliefs that are so often held by teachers in the United States actually serve to block any real mathematics reform within the classroom (Yates, 2006). So in order to move forward with mathematics education reforms, we must first begin to understand the significant role that beliefs play in determining our conception of the nature of mathematics, the nature of mathematics teaching, and the process of learning mathematics. Thus, researchers have begun to focus their efforts on the more cognitive, psychological or even philosophical field of beliefs.

The vast amount of beliefs research that exists can roughly be categorized into three main areas. The first is research that focuses on the analysis and classification of the beliefs of teachers. This includes describing the structure/formation of beliefs and belief systems (e.g. Ambrose, 2004; Cooney, 1998; Ernest, 1988; Op't Eynde, 2003). The second area includes studies that focus on the link between teachers' beliefs and their teaching practice (e.g. McNab,2004; Skott, 2001; Sztajn, 2003; Thompson,1984). The final area is research that describes and monitors changes in teacher's beliefs over a period of time (e.g. Ensor, 2001; Fennema, 1996; Szydlik, 2003). I must caution, however, that this categorization of the research is not intended to imply that beliefs studies are easily categorized, separate, or unrelated to one another. On the contrary, beliefs research is complex, comprehensive and interrelated. For example, how can one talk about changes in beliefs without suggesting their effect on teaching practice, or how can research describing changes in beliefs take place without first being able to define beliefs? Instead, I am simply using these categories to help make sense of the vast amounts of research that exist in this area.

Beliefs Systems

One of the greatest difficulties faced by those who choose to study the beliefs of others is being able to accurately obtain a picture of another human beings conceptions about mathematics and the teaching of mathematics. As Parjares (1992) pointed out, the difficulty in studying beliefs is that, “many see it so steeped in mystery that it can never be clearly defined or made a useful subject of research”(p. 232). Yet, many researchers have chosen to undertake the complicated task of defining and analyzing the beliefs of teachers and have agreed that this is the point where beliefs research must begin. As Parjares (1992) observed, “ It will not be possible for researchers to come to grips with teachers’ beliefs… without first deciding what they wish belief to mean and how this meaning will differ from that of similar constructs” (p. 308). Leatham (2006) pointed out that beliefs research often glosses over the definition of belief and completely ignores the idea of a belief system. This area of research emphasizes the importance of defining the term belief and then examines how beliefs are formed and related to each other. Researchers such as Pajares (1992) have spent a great deal of time and energy in an attempt to establish a widely accepted definition of the term belief but as of today no common, universally accepted definition exists (Goldin, 2009).

Others (e.g. Ernest 1988) have spent an equal amount of time trying to define the structure of our beliefs systems making the study of the formation or structure of beliefs a topic of interest. Cooney et,al. (1998) stressed the importance of understanding not only what teachers believe but also how these beliefs are structured and held so that it will be possible to have an impact on the further development of these beliefs. Leatham (2006) agreed, that developing the idea of a belief system and how this system is related to practice is important. Many of those who study the structure of teachers’ beliefs have used Green’s (1975) theoretical framework to guide their research. This framework encourages researchers to look at several dimensions when describing beliefs including their relative strength, their relationship to one another, their classification as either peripheral or central, and the effect of external forces on them (Cooney, 1998). But even with a well-established framework such as Green's we find that it continues to be an incredibly difficult task to obtain an accurate picture of the beliefs held by teachers.

Of particular concern for obtaining information on how beliefs are structured and held is the fact that many teachers may not consciously be aware of many of their beliefs and are thus unable to articulate them (Ernest, 1988, Leatham, 2006). Obtaining an accurate picture of an individuals explicitly stated beliefs is a difficult enough task but trying to obtain a valid understanding of those beliefs that are implicit has been a near impossibility. It has not been until very recently that researchers have begun to suggest new ways for obtaining a more accurate picture of the beliefs held by teacher. Leatham (2006) suggested in his sensible system framework that teachers be treated as sensible, rational individuals by assuming that it is an impossibility for a teacher's actions to be irrational and counter to the beliefs they hold. Adopting this new perspective allows researchers to look more deeply at both the implicit and explicit, mathematical and non-mathematical beliefs that are held by practicing teachers. It also allows the researcher to examine how beliefs interact with one another and in turn how they affect classroom practice.

Beliefs and Teaching Practice

In the past two decades, mathematics educators have become increasingly interested in the relationship between what teachers believe about mathematics and the way teachers teach mathematics (Cooney, 1998; Hart, 2002; Thompson, 1984). Whether or not beliefs have been defined or left undefined, it is clear that they are fundamental to the effective teaching of mathematics. In fact, many studies found a strong relationship between teachers' beliefs about the nature of mathematics and the teaching of mathematics and the development of instructional practice (e.g. Szydlik, 2003; Hart, 2002; Thompson, 1984). These studies have suggested that, not only do the beliefs teachers hold about student learning and teaching influence their classroom practice, but their beliefs about the nature of mathematics also impact practice. Interestingly, research shows that beliefs about the nature of mathematics strongly influence the way that teachers convey material to their students. Some studies go even farther claiming that the beliefs and attitudes of teachers are significant determinants of the way that they view their role as educators not just factors in the way they conduct their classrooms (McNab, 2003, Yates, 2006).

A vast majority of studies in this area of beliefs research focus on the perceived inconsistencies between the teacher's professed beliefs and actual teaching practice (e.g. Cooney, 1998; Raymond, 1997; Thompson, 1984). Often, these studies examine the espoused beliefs of preservice or novice teachers and their classroom actions. Various reasons have been given for these observed inconsistencies. Some researchers claim that these inconsistencies are caused by institutional and contextual constraints that force teachers to act differently then their stated beliefs. Other researchers claim that beliefs are the result of practice rather than a main influence on it (Skott, 2001). Still others (e.g., Cohen, 1990) have suggested that teachers are irrational and may simply act in a way that is contrary to their stated beliefs. More recent research (e.g., Leatham, 2006) has suggested that these claims of an apparent disconnect between teacher's beliefs and actions, found in so much of belief's research, actually may not exist. Instead, it may just be a failure on the part of the researcher to correctly identify the beliefs held by the teacher or perhaps it is a failure to correctly interpret what it is that he is hearing or observing. Natasha Speer (Leatham, 2006) argued that researchers interpret teachers' expressed beliefs through their own lenses and so they may not be getting a clear picture of what the teacher really means. She claimed that the current research methods do not probe deeply enough to uncover the beliefs a teacher holds and so it is understandable that researchers looking at a teacher from their perspective will find discrepancies between their expressed beliefs and actions, whether these differences are real or not.

Another focus of the research in this area emphasizes the importance of how teachers view mathematics. Several studies have shown that teachers who view mathematics as a set of rules and facts to be memorized and applied are more likely to teach in a procedural manner that emphasizes memorization and application of rules (Szydlik, 2003). Szydlik (2003) pointed out that most preservice elementary teachers see mathematics as an authoritarian discipline and for them doing mathematics simply means applying rules and formulas to mathematical equations. Cooney (1998) explained that these beliefs about mathematics as an unconnected set of rules are formed long before preservice elementary teachers enter their college studies and that the current traditional environment in which mathematics is learned perpetuates these beliefs. Szydlik (2003) explained further that in these traditional settings students are taught to rely on external authorities such as their instructor, textbook or curriculum guide to determine mathematical validity rather than on themselves. Additionally, research on beliefs shows that a teacher who sees mathematics from a problem solving perspective is more likely to guide students to form their own mathematical constructions through exploration, sense making and logical deduction (Szydlik, 2003).

Teachers' beliefs are at the heart of changing approaches to teaching and learning mathematics. Mathematics teachers of today are expected to embrace a problem solving approach as the means for teaching important mathematics. In a narrow sense, this approach can be described as an activity directed toward a goal where the student does not initially know how to reach that goal (Goldin, 2009). More broadly, problem solving can be seen as a means for designing and implementing effective mathematics instruction and learning. In recent years, the NCTM (2000) has encouraged reform throughout school mathematics and has suggested the problem solving approach to teaching school mathematics as a means for such reform. This important change and its connections to beliefs is explained by Ernest (1988):

> Such reforms depend to a large extent on institutional reform: changes in the overall mathematics curriculum. They depend even more essentially on individual teachers changing their approaches to the teaching of mathematics. Teaching reforms cannot take place unless teachers' deeply held beliefs about mathematics and its teaching and learning change (p. 99).

As Ernst suggested, without first establishing a willingness to develop the appropriate, deeply held beliefs about mathematics and the teaching of mathematics, any reform effort is doomed to fail. If change is to be effective and sustainable, teachers need to possess adequate beliefs about mathematics and the teaching of mathematics (Goldin, 2009). The suggestion that an openness to establishing appropriate beliefs needs to be present before reform is attempted is often ignored. Without these beliefs, research shows that teachers who hold incompatible or incomplete beliefs about reform efforts will be unable to successfully implement any real change. Szydlik (2003) stressed the importance of understanding the beliefs held by preservice teachers, noting:

> If we are to educate future teachers who are able to lead mathematical explorations and to allow their own students to construct mathematics, that is, if we are to help them teach in a way consistent with current calls for reform (NCTM, 2000), we must help them see mathematics as a discipline that makes sense (p. 254).

The first year teachers in this study have been identified as those that have developed and posses beliefs that are progressive and in line with current understandings about best practices within the mathematics classroom.

Although the complexity of the relationship between teachers' beliefs and their teaching practice has yet to be completely untangled, most researchers agree that teachers' beliefs about mathematics and the teaching of mathematics, whether consciously or unconsciously held, play a significant role in shaping the teachers' instructional behaviors (Benbow, 1995, Thompson, 1984). Pajares (1992) indicated that beliefs have always been the best indicator of the decisions made by individuals. It is clear that beliefs play an important role in teaching and that "powerful and effective decision making" is influenced deeply by the beliefs teachers hold (Goldin, 2009, p.7).

Changing beliefs

A third area of beliefs research that has received a great deal of attention is research that attempts to describe changes in teacher beliefs or beliefs systems. This area of research seems to adopt the guiding principle that in order to make any real change in an individuals understanding of mathematics and the teaching of mathematics, a process of change in internal mental states must take place, often through an intensive program designed to encourage these changes (Ernest, 1988; Hart, 2002). Yates (2006) pointed out that the many failures in curriculum reform in mathematics education occur because of a lack of congruence between curriculum innovation intent and teachers' pedagogical knowledge, beliefs and practices. To make any real change in mathematics education, some researchers have suggested that the individual's beliefs must first be challenged and this conflict with their currently held beliefs must then be resolved by accommodating these new insights into the existing belief system. To create this conflict teachers must become dissatisfied with their currently held beliefs. Trying to create this conflict and encourage change can be a challenging undertaking as beliefs are developed through numerous experiences, over long periods of time and have been shown to be relatively stable and resistant to change (Cooney,1998; Goldin, 2009). It has also been suggested that beliefs about the nature of mathematics must first be changed in order to implement the teaching practices promoted by the NCTM standards (Raymond, 1997). Deeply held, traditional beliefs about the nature of mathematics have the potential to perpetuate mathematics teaching that is more traditional so to move teachers toward more progressive teaching methods they must first adopt less traditional ideas about the nature of mathematics (Raymond, 1997).

Many researchers have found that simply completing an early elementary education program that includes mathematics education courses is not enough to effectively change the beliefs about mathematics and the teaching of mathematics of preservice elementary teachers. There are many studies (e.g. Raymond, 1997) that suggest that teacher education programs, unless specifically designed to help change beliefs, have little influence on teacher beliefs or practice. In fact, some research asserts that the beliefs that preservice teachers arrive with often grow stronger during their education program (Cooney, 1998). This may be due in part to the fact that beliefs about mathematics are established over a long period of time, well before students enter college and without a concentrated effort will not be changed (Pajares, 1992). Teachers participating in this study were part of a carefully designed, field intensive, early childhood program that promoted the reform effort suggested by NCTM (2000) and encouraged the growth of beliefs that supported these ideas. As a result, all of the students chosen for this study held progressive beliefs about mathematics and the teaching of mathematics prior to entering their first year of teaching.

Much of the current research on changing beliefs occurs in the context of teacher education. These studies focus on how preservice teachers' beliefs change over time and the difficulty associated with changing these beliefs. The majority of these studies examine how preservice teachers' beliefs changed after completing a sequence of well-designed courses in their college program. (e.g., Cooney, 1998; Hart, 2002; McDiarmond, 1991). There are far fewer studies that are situated in a more natural environment and not within the context of teacher education (e.g. Ensor, 2001; Hart, 2002; Zeichner, 1981). Even studies on practicing teachers often look at how beliefs are changed during specific, well-designed teacher training courses and not within the context of their own school or classroom. Cooney (1998) offered an explanation for this, noting that changes in beliefs seldom occur without some form of significant intervention, which is not likely to occur naturally within the classroom. Hart (2002) also supported this idea by pointing out that most beliefs are formed through experiences over time and a single event is unlikely to significantly change beliefs. Thus, this significant intervention that is given over a time period is often found in the form of college classes or extensive teacher training courses and not in everyday teaching. In this study, however, I hoped to help fill this gap by looking at how beliefs change in the first year of teaching within the natural setting of the classroom and not in an artificial environment.

Not unexpectedly, there appears to be a strong connection between teacher education programs and the changing of beliefs (Cooney, 1998, Zeichner, 1981). However, researchers caution that these experiences within teacher education programs do not guarantee sustainable changes in beliefs (Hart, 2002). It is commonly accepted that teachers who develop more progressive or liberal views about education during their university studies often shift back to more traditional views as they move into student teaching and inservice experience (Zeichner, 1981). “This progressive-traditional shift in professional perspectives is assumed to be a result of students being caught between the conflicting demands exerted by the schools and universities” (Zeichner, 1981, p.7). This suggests that teachers’ beliefs are most likely affected by other influences outside the university classroom such as their own schooling, more general beliefs about education and how students learn, peer expectations, or perhaps even by their own experiences working with children. For example, McDiarmond (1991) found that after a focused, in-depth, semester long experience within a non-traditional mathematics classroom, several students did begin to reconsider their initial, more traditional beliefs. However, many students still clung to them. Instead of embracing what they had experienced, these students chose to rationalize what they saw in the context of their more traditional beliefs to explain why the non-traditional methods of teaching appeared to be so effective. These students felt that they had observed an exceptional group of “gifted students” and that other “regular” students would not be as successful (McDiarmond, 1991). This concern for student achievement, as demonstrated by these preservice teachers, is often a deterrent to making changes in beliefs and in turn teaching methods. In spite of the evidence presented, their concern for student achievement caused these preservice teachers to continue to believe that more traditional ways of teaching mathematics were better for all students. This concern for student achievement is shared by many teachers. Guskey (Skott, 2001) has even suggested that student learning is the greatest determinant of how teachers evaluate their teaching practice. Because of this concern, he suggested that few changes in teachers' beliefs can be expected before increases in student learning are documented (Skott, 2001).

Beliefs and the First Year of Teaching

In the United States, almost all elementary school teachers are required to teach mathematics, but without proper preparation many lack the essentials necessary to be successful within the classroom. Evidence suggests that to be successful, especially in the first years of teaching, elementary teachers not only need to increase their understanding of mathematics but also challenge their existing beliefs about the nature of mathematics and the teaching of mathematics (Yates, 2006). Volumes of research support this claim and demonstrate a clear link between beliefs, teaching practice and student learning (Benbow, 1995, Thompson,1984). Schoenfield (1992) has even argued that a stronger link exists, suggesting causality in that teachers' beliefs about the nature of mathematics directly determine the nature of the classroom environment. Other researchers insist that the link is less clear- that the complexity of the relationship defies the simplicity of cause and effect (Thompson, 1984). A few even go so far as to propose that beliefs and classroom practice are unrelated.

If we are to believe that teachers' actions are indeed related to their beliefs, as this study proposes, then any attempt to improve the quality of mathematics teaching must begin with an understanding of the beliefs held by novice teachers and how these relate to their teaching practice (Thompson, 1984). In investigating beliefs, many studies have found that preservice and beginning teachers' beliefs about the nature of mathematics are often more traditional than their beliefs about mathematics teaching (Raymond, 1997). It has been widely accepted that before they can truly adopt the reform efforts proposed by NCTM (2000), teachers must first adopt a set of beliefs that embrace these new ways of addressing mathematics. One way that teacher educators have tried to provide challenges to their student's existing beliefs is through early field experiences (Benbow, 1995). These experiences, which are becoming more and more common in teacher education programs, can be seen as a response to critics who describe teacher education programs as too abstract and academic (McDiarmond, 1991). By providing these early experiences it is hoped that students will strengthen their progressive beliefs about mathematics and the teaching of mathematics so that they can withstand the challenges of the classroom. It is also hoped that these experiences will help increase their understanding and appreciation for the essential knowledge that they are receiving in their education courses because they will be able to experience an immediate need for it. These field-based experiences allow preservice teachers the opportunity to struggle with making decisions about how to approach the teaching of mathematics before they become teachers. But do these classroom experiences really strengthen progressive beliefs and do they always have a positive impact on the beliefs of these young teachers?

While many studies have been designed to encourage change in the beliefs of teachers during their preservice experience (e.g. Hart, 2002; Szydlik, 2003; Wilcox, 1992), few have examined whether and how these changes in beliefs have been sustained through the beginning years of teaching (Artz, 2003). Within mathematics education there are few longitudinal studies exploring this sustainability of beliefs. Even though there is little research and certainly no consensus on the effects of first year teaching on beliefs, one point that researchers do seem to agree on is that novice teachers, especially those with newly acquired progressive beliefs, are faced with many challenges and constraints in their first year. They also seem to agree that these constraints serve to challenge the beliefs of these young teachers. But this seems to be where the agreement stops. Researchers in the teacher education community have suggested many opposing views about the effects of early field experiences and first year teaching on the beliefs of teachers. Some researchers have claimed that these challenges cause students to change or restructure their beliefs, others claim that students revert back to previously held beliefs, some claim that students will act in direct conflict with their stated beliefs, while a final group believes that the beliefs are not changed or easily abandoned just misinterpreted.

Examining how beliefs interact with other factors faced in early field experiences and more so in the first year of teaching is an important area of research. Much of the current beliefs research in this area focuses on the perceived disconnect between the novice teachers' espoused beliefs and the actions taken within their classrooms. These inconsistencies are often attributed to the challenges and constraints that young teachers must face in their early years of practice (e.g. Cooney, 1985; Skott, 2001; Thompson, 1984). Research that adopts this perspective suggests that because teachers work under constraints, the link between beliefs and practice is weakened, allowing teachers to act in opposition to their stated beliefs (Raymond, 1997; Thompson, 1984). Because new teachers often form their beliefs about the teaching of mathematics during their years in carefully designed college courses, they often form them by envisioning themselves in prefect, imagined classrooms behaving in specific and precise ways. These envisioned behaviors, however, are rarely the behaviors observed by researchers who enter the classroom with their own ideas about how a person's stated beliefs should be manifested within the classroom. Instead, researchers often observe what they describe as behaviors that conflict directly with stated beliefs. Liljedahl (2009) provided an explanation for the possible conflict. He suggested that young teachers "fail to realize their intentions in the face of a reality that does not match the envisioned environments and encounters for which their intentions were constructed" (p.33). Raymond (1997), as do many other researchers, maintained that beginning elementary teachers often enter the profession with non-traditional beliefs, but when faced with the constraints of the real classroom they tend to implement traditional, show and tell practices, not the practices anticipated by researchers aware of their stated beliefs. Instead of suggesting a real change in beliefs, these researchers propose that it is possible for teachers to hold certain beliefs but to act in a way that is counter to those beliefs.

In defending the view that teacher's actions and beliefs do not have to be wholly consistent, researchers have looked to other factors to explain these identified inconsistencies. Two underlying factors that have been identified include social teaching norms (parent, student and administrator expectations, an institutionalized curriculum, and standardized assessments) and teachers' abilities to reconcile their beliefs and integrate them with classroom practice (MacNab, 2003; Raymond, 1997; Thompson, 1984). This combination of beliefs, social context and level of thought relating beliefs to practice underlies the complexity of teaching mathematics (MacNab, 2003). This idea of teachers behaving counter to their beliefs is particularly troubling in relation to first year elementary teachers as it has been suggested that these teachers have very fragile belief systems that are particularly susceptible to outside influences (Cooney, 1985; Raymond, 1997).

Historically, many researchers have claimed that preservice teachers become increasingly more progressive in their beliefs about mathematics and mathematics education while in their teacher education programs but then tend to shift back to more traditional beliefs once they enter the classroom (Zeichner, 1981). They claim that teacher preparatory programs tend to move students toward more open and accepting beliefs about mathematics and away from the rigid, right or wrong beliefs they entered the program with but these new beliefs do not hold up in the first years of teaching. A group of researchers has expressed concern that internal and external obstacles found in the first years of teaching may impede new teachers from implementing the reform-based instructional practices to which they subscribe during their college preparation (Artz, 2003). Many claim that the impact of the college experience on the beliefs held by students is "washed out" once they enter full time teaching (Zeichner, 1981). It has been suggested that these obstacles actually cause new teachers to revert back to the more familiar, traditional practices that they experienced throughout their schooling (Wilcox, 1992). Other researchers argue that, although first year teaching does present challenges, it is actually the years a student has spent within the classroom observing other teachers that negates the impact of progressive college preparatory programs. In a study of first year teachers, Artz (2003) found that students who entered their teacher preparation programs with rigid, traditional educational backgrounds appeared to revert back more often to a lecture oriented approach to teaching than did their peers with a less rigid educational background. Those that enter the program with well-established, progressive beliefs were much less likely to employ traditional methods of teaching. All of the views mentioned above are particularly unsettling to mathematics educators. It is difficult to accept that the beliefs teachers form throughout their college experiences are so easily dismissed once they enter the classroom and so it causes us to search for alternative explanations.

While many researchers argue that teachers' classroom behavior and choices can be inconsistent with the beliefs that they hold, others offer an opposing view. There are researchers, including myself, that maintain that teachers' beliefs and practice are always consistent regardless of other contributing factors (Leatham, 2006, Raymond, 1997, Skott, 2001). If teachers are assumed to be rational beings, as was done during this study, then teachers' actions and beliefs cannot be seen as inconsistent. Instead, beliefs are seen as filters that serve to filter out the complexity of a situation, to make it comprehensible, and compel teachers to act in a particular ways (Ambrose, 2004). When faced with challenging decisions, it is the beliefs of new teachers that compel them to act in particular ways and thus their actions cannot be counter to the beliefs they hold (Ambrose, 2004). To explain the inconsistencies reported by other researchers, researchers who hold the view that beliefs and practice are not inconsistent often distinguish between the level of beliefs held by teachers such as deep and superficial. This perspective offers alternative interpretations for teachers' perceived inconsistencies. A leveling of the beliefs allows the researcher to claim that a belief was only superficially held when an inconsistency is observed and thus the inconsistency can easily be dismissed because the belief was not solid. It also allows the researcher to see first year teachers' actions as logical and, perhaps, more in line with their deeply held beliefs. Another explanation for the perceived inconsistencies is that teachers also posses beliefs that are general and not specific to teaching mathematics, and it is these beliefs that may be compelling them to act in a certain way (Thompson, 1984). For example, Skott (2001) showed how a teacher's beliefs about students' self esteem took precedence over his belief about mathematics teaching.

Even researchers who claim inconsistencies in beliefs and actions often, inadvertently, support the idea of consistency. For example, Raymond (1997) described what she interpreted to be an inconsistency in beliefs and practice in a first year teacher's classroom experience. Raymond discussed a teacher who had stated that she believed that cooperative learning is the best way to learn mathematics but, because of classroom management concerns, she did not often use this method. In trying to explain why the teacher behaved in direct conflict with her beliefs, Raymond actually provided us with evidence to suggest that the first year teacher's beliefs were not inconsistent with her actions. By pointing out that this teacher was more concerned about discipline, we see the possibility that her beliefs about classroom management and perhaps the way she is seen by other teachers and administrators were taking precedence over her beliefs about the teaching of mathematics and was perhaps a more deeply held belief. This explanation implies that she was not behaving in direct conflict with what she believes but that there were other logical explanations for her actions and for the researcher's observed inconsistencies.

One of the goals of mathematics education research is to determine the factors that are involved in shaping mathematics instruction and in turn improving student learning. It is clear from the volumes of existing research that beliefs play an important role in reaching this goal and improving mathematics instruction. Whether teachers are consciously aware of their beliefs or not, it is clear that they do influence classroom practice. However, it is equally clear that teachers' beliefs systems are complex and the relationship between them and instructional practice is not simple. In t his study I attempted to help unravel a small piece of this complicated beliefs puzzle. By looking at how progressive beliefs withstand the challenges of first year teaching and by identifying some of constraints commonly faced in these years, I hoped that this research would inspire improvements in teacher education programs that better prepare young teachers for the challenges of first year teaching. I also hoped that this research would inspire improvements within school systems so that they will be able to provide the appropriate support to all teachers working toward implementing the new reform curriculum.

Theoretical Framework

I chose to use Keith Leatham's (2006) sensible system framework for my research. The sensible system framework has both theoretical and methodological implications. It proposes a theoretical basis for the definition of belief and for the organization of belief systems (Leatham, 2006). In his discussion of the organization of belief systems, Leatham (2006) addresses the idea of belief clusters and the levels at which a belief is held. For this research, it was not necessary to distinguish how or at what level a belief was held so no attempt to classify beliefs in this way was made here. The framework also suggests that belief systems are always logical to the individual holding them and it does not allow for contradictions in beliefs or between beliefs and actions, thus having some important methodological implications that will be discussed later.

This framework also suggests that teachers are complex, rational individuals who have reasons for the decisions they make and that their beliefs influence their actions. This description of teachers allowed me to view them as consistent, sense-making individuals rather than inconsistent beings. By adopting this framework I was able to avoid some of the common pitfalls associated with research in the area of beliefs. Instead of focusing on the inconsistencies between teachers' actions and their stated beliefs, I was able to look more deeply at the beliefs themselves and what beliefs might be causing the perceived action. I was also able to assume that teacher's actions are not irrational and counter to their stated beliefs about mathematics and the teaching of mathematics but that they made sense in relation to other, possibly more strongly held beliefs. By using this framework it was my hope to be able to determine whether real changes in beliefs about mathematics and the teaching of mathematics occurred within the first year of teaching.

Before beginning my research I first had to determine what I meant by the term beliefs. As Pajares (1992) pointed out, researchers must first decide what beliefs mean and how to distinguish them from other constructs before they can begin to understand what beliefs teachers hold. The sensible system framework also stressed the importance of distinguishing between the varying interpretations of this term and developing an understanding of what is meant by the term beliefs. Leatham (2006) described his interpretation of beliefs and the distinction between what we refer to as knowledge and what we refer to as purely beliefs in the following way:

> In the sensible system framework, the following distinction is made: Of all the things we believe, there are some things that we "just believe" and other things that we "more than believe – we know." Those things we "more than believe" we refer to as knowledge and those things we "just believe" we refer to as beliefs. Thus beliefs and knowledge can profitably be viewed as complementary sub-sets of the set of things we believe. It is in this sense that belief is used in the sensible system framework. (p. 92)

For my research, I adopted this definition of beliefs. In the past, educational theories have been based on the assumption that knowledge is separate from beliefs and that it is a relatively stable characteristic (Goldin, 2009). Many, however, have suggested quite the opposite. Some researchers conclude that knowledge structures are not independent and that they are primarily belief structures (Goldin, 2009; Leatham, 2006). For this research, no distinction was made between knowledge and beliefs as knowledge was seen as dominated by a larger set of beliefs. In other words, both knowledge and specific beliefs about mathematics and the teaching of mathematics are seen as sub-sets of a much larger set of beliefs. This definition allowed me to look at beliefs as flexible and accommodating instead of as a rigid and easily categorized construct.

Once a working definition of beliefs was established, I then had to determine how to ascertain the beliefs of the teachers being studied. Because beliefs are highly individualized, the sensible system framework provided me with not only a theoretical framework for my research but also methodological implications for inferring the beliefs of each individual teacher (Leatham, 2006). Much of the research on beliefs operates under the assumption that teachers are able to easily articulate their beliefs and that the researcher and teacher interpret these stated beliefs in exactly the same way (Leatham, 2006). However, this assumption can often result in misinterpretations of teachers' beliefs and in researchers' poorly substantiated declaration of inconsistencies between teachers' beliefs and their beliefs and actions. Because teachers often find beliefs difficult to articulate and in some circumstances may even be unaware of the beliefs they hold, beliefs must be inferred and thus it can be very difficult to find an effective way to measure them (Ambrose, 2004). In fact, Leatham (2006) suggested that individuals may not even be consciously aware of some of the beliefs they hold or if they are aware, they may or may not be able to articulate those beliefs accurately to someone else. This suggests that it is inadequate to simply ask someone about their beliefs about mathematics and the teaching of mathematics (Leatham, 2006). As Pajares (1992) pointed out the beliefs held by an individual cannot be found through direct observation or simply by asking them what they believe. Instead, the beliefs must be inferred through what the individual says, intends, and does. Through the use of the sensible system framework I was encouraged to use a variety of methods to obtain information about the beliefs of teachers in order to minimize any inconsistencies in interpretations of the beliefs.

One major assumption by the sensible system is that beliefs are interrelated. In order to make sense of what a person believes, the researcher must examine how these beliefs are related to one another. The sensible system framework presumes that individuals organize their beliefs into systems that make sense to them (Leatham, 2006). Cooney (1998) also supported the idea of beliefs as systems and not as singular entities. Under this assumption, beliefs are seen as fluid and pliable so that when a new belief is introduced other beliefs are adjusted to accommodate this new belief into the system. Thus beliefs become viable for an individual when they make sense in relation to that individual's other beliefs (Leatham, 2006). This sense making implies that individuals must develop an internally consistent and organized structure of beliefs that does not allow for contradictions between beliefs or between actions and beliefs. Under the sensible system, whenever an individual encounters what might be seen as contradictory beliefs, the individual finds a way to resolve the conflict within the system and thus eliminates the possibility for contradictions. For the researcher, when employing the sensible system framework, presumed contradictions are seen as perturbations in our own sense making and provide us with the opportunity to learn more about how the individual is structuring this particular belief within the system; we cannot just assume that we have encountered an inconsistency (Leatham, 2006).

Much of the current research on the connection between teacher beliefs and actions is based on the assumption that teachers can simultaneously articulate their own beliefs and be inconsistent in their actions with respect to those beliefs (Leatham, 2006). If we believe, as I do, that teachers are rational, sensible beings then we must reject this assumption and embrace an alternative explanation. This alternative can be found in Leathm's sensible system framework. While assuming that beliefs are predispositions to actions, the sensible system framework presumes that individuals are sense-making beings and therefore develop their beliefs into organized systems that make sense to them but not necessarily to the researcher (Leatham, 2006). By assuming that belief systems are sensible and that beliefs are interrelated, we eliminate the possibility of contradictions between individuals' actions, intentions, and beliefs. Thus when teachers behave in a way that seems inconsistent with their beliefs, it is assumed that the inconsistency is not with the teacher but with the observer's inferred beliefs of the teacher. This assumption allowed me to look more deeply at what might be causing any observed inconsistencies; perhaps it was simply a misunderstanding of the implications of the stated belief or perhaps another, stronger belief had taken precedence over the original beliefs, or perhaps the teacher's beliefs had changed over time.

Current research presupposes that teachers' beliefs about mathematics are the core beliefs influencing their teaching of mathematics and that these beliefs will have the strongest influence on the pedagogical decisions made by these teachers (Leatham, 2006). This assumption can be dangerous and may be the reason why so many researchers have found inconsistencies between a teacher's actions and her stated beliefs. By making this assumption researchers rule out the possibility that other beliefs, such as general beliefs about teaching or how children learn, may be taking precedence over the teacher's beliefs about mathematics and the teaching of mathematics. Skott (2001) suggested that, in certain situations, other more general beliefs about teaching and learning will supersede beliefs about mathematics and the teaching of mathematics. He cautioned that this should not be interpreted to mean that the teacher has abandoned her beliefs about mathematics but that other beliefs are currently being acted upon. The sensible system framework also removes the assumption that mathematical beliefs are the only beliefs that control teachers' decisions about the teaching of mathematics. Once again this framework forces the researcher to take a deeper look at what beliefs are driving teachers' actions. If the delivery of a mathematics lesson appears to be inconsistent with the stated beliefs of the teacher then the sensible system encourages the researcher to assume that the teacher is acting logically and to look for the underlying reasons for her actions. The framework encourages the researcher to search for consistency within the teacher's stated beliefs and actions and to more deeply explore and explain these apparent inconsistencies rather than just pointing them out (Leatham, 2006).

In conducting this research I assumed that I would find that first year elementary mathematics teachers had very fragile belief systems about mathematics and the teaching of mathematics. I also expected their most recently formed beliefs, such as those acquired during their mathematics education courses, would be the most fragile and easily changed. Using the sensible system framework, I was able to thoroughly explore the beliefs of the teachers in the study and assume that inconsistencies between stated beliefs and between beliefs and behaviors did not exist. Instead, when inconsistencies were observed, I was forced to search more deeply for the cause of these perceived inconsistencies. By employing this framework I hoped to determine whether these teachers' beliefs actually changed during their first year of teaching or whether their beliefs remain unchanged. The framework also allowed me to determine whether beliefs that appeared to change really had. It forced me to look for alternative explanations to determine whether real change had occurred. Explanations such as more general beliefs taking precedence over their beliefs about mathematics and the teaching of mathematics or perhaps the teacher's understanding of a question, phrase or word had changed over time and they are not interpreting it as the researcher intended were considered.

CHAPTER 3

Methodology

The goal of my study was to determine whether changes in beliefs about mathematics and the teaching of mathematic occurred during the first year of teaching. In addition, it was my hope to identify some of the challenges/constraints faced by these first year teachers that might have an impact on their beliefs. Qualitative research methods were used in this study to determine whether any changes occurred during the first year of teaching. These methods can be best characterized as the purposeful selection of participants, the use of a wide variety of data sources, and the thorough analysis of data using Keith Leatham's Sensible System framework (2006).

Setting

The first phase of the research was conducted at a small liberal arts college of about 6000 students, located in a small town in central Georgia. The college was founded in 1889 and is accredited by the by the Commission on Colleges of the Southern Association of Colleges and Schools to award associates, baccalaurate, masters and specialist degrees. The student population at the institution is among the best in the state with students academically with students ranking third highest in average Scholastic Aptitude Test scores. Participants for this study were chosen from the College of Education's early childhood cohorts.

The second phase of the research was conducted both at the college and at several elementary schools in Georgia. Upon graduating from the institution, four of the five participants of the study found work in the central Georgia area and one in south Atlanta. Four of the preservice teachers accepted jobs as second grade teachers and one accepted a position as a prekindergarten teacher. During this phase of the research, I was able to visit four of the five elementary schools where the new teachers were working. Because of county restrictions on conducting research within the schools, I was not allowed to visit one of the schools. The school settings varied dramatically both in physical appearance and in student make up.

I conducted interviews with each of the teachers on site after each observation. Some were conducted within the classroom while others were conducted in libraries or conference rooms. One interview was even conducted on the playground. Interviews for the teacher that I was unable to observe were conducted on the college campus in the mathematics conference room. A final interview with all five of the participants was also conducted in the mathematics conference room on campus.

Program Description

The preservice teachers selected for this study were all participants in the early childhood program at a small liberal arts college. The undergraduate program in early childhood education successfully used a cohort model for the preparation of elementary teachers. The transition from a more traditional model of teacher education to the current innovative field-based teacher preparation program was completed in 1996. With this model, the college stepped to the forefront in initial preparation of teachers for certification in both elementary and middle grades education. Students involved in the elementary cohort model were exposed to an innovative program that has been refined over the past ten years.

In the cohort model, the preservice teachers for this study were assigned to a mentor leader and placed in small groups of approximately 20 students during their junior and senior year of study. This model of teacher education enhances the opportunities for these preservice teachers to share similar experiences and develop skills for collaboration that are necessary to become successful teachers.

There are three critical elements to the early childhood program at this liberal arts institution. One of the unique and key elements to the success of this field-based program is the *Mentor Leader* – a person who is experienced both as a classroom teacher and as a teacher educator. The Mentor Leader begins and ends the two-year program with a cohort creating a strong bond between the preservice teachers and their mentor leader. A second critical element to the program is the variety of experiences provided and time spent in elementary classrooms. During the junior year, the preservice teachers were placed in four different school settings, with two placements each semester. They spent 16 – 20 hours each week in a classroom under the guidance of a host teacher who was specially selected to supervise the student. In their senior year, the preservice teachers spent an entire semester in a single placement and, if progressing appropriately, were allowed to stay with the same host teacher for an entire year. The final unique element of this innovative program is the ethic of collaboration that permeates it. So strongly is collaboration emphasized in this program that it is one of the focal points that must be addressed by seniors in their exit portfolios.

As part of their early childhood program, participants in this study were required to successfully complete two mathematics courses and three mathematics education courses. The first two mathematics courses were required for completion of the core curriculum. Students choose from a variety of entry-level courses to fulfill these requirements, including mathematical modeling, pre-calculus, survey of calculus, calculus, linear algebra, or elementary statistics. Decisions about these courses were made through consultation with an advisor in the College of Education and were based on the student's mathematical background and declared interests; however, because of the renewed focus on statistical ideas in the elementary classroom, all cohort students were strongly encouraged to select elementary statistics as one of their chosen classes.

Upon entering the cohort in their junior year, the participants were required to take three mathematics education courses. The sequence of mathematics education courses was purposefully designed to encourage a change in the beliefs held by most entering preservice teachers from a traditional view of mathematics and the teaching of mathematics to a more progressive view as described in the NCTM standards. The first of these courses is an introduction to mathematical problem solving. This course was designed to expose prospective elementary teachers to a variety of problem solving strategies. It is the goal of this course, and all mathematics education courses at the college, to foster an in-depth understanding of elementary mathematics, to encourage cross-disciplinary thinking, and to promote effective mathematical communication both orally and in writing. These goals are accomplished by exposing students to a wide range of mathematical topics and a variety of pedagogical strategies that enhance the development of their mathematical thinking as well as the mathematical thinking of their future students.

The other two mathematics education courses that the preservice teachers take are more content focused. The first course focuses on the development of ideas about number and operations while the second course centers around geometric and statistical concepts. Even though content is the primary focus of both of these courses, other aspects of teaching mathematics are not ignored. Preservice teachers again are exposed to a wide range of pedagogical strategies specifically focused on the teaching of mathematics. In addition, they are introduced to current research relating to the topic at hand.

The curriculum design and the field experiences of the early childhood program not only helped the participants to develop a profound understanding of the mathematics that they teach but also helped them develop a knowledge of students' mathematical thinking. In addition, it exposed them to the appropriate use of numerous technologies, which included a heavy focus on the appropriate use of manipulatives, and to a variety of pedagogical strategies that can enhance the development of their students' mathematical thinking. Many students who successfully complete the courses, including all five of the participants in this study, leave the cohort program with a set of beliefs that are conducive to the teaching and learning of mathematics as discussed in the NCTM standards.

Participant Selection

All senior early childhood preservice teachers (n = 63) in their final mathematics education course participated in the first phase of my research. These students were selected from three separate cohorts, each consisting of approximately 21 students. Of the 63 participants, 3 were black, 1 was Asian, 59 were white, 3 were male and 60 were female. All of the participants were in their final year of the early childhood teacher preparation program and were scheduled to enter the teaching profession in the fall of 2008. Each of these preservice teachers had successfully completed 2 core level mathematics courses chosen from mathematical modeling, pre-calculus, statistics, trigonometry or calculus. By the end of the first phase of my data collection they had also completed 3 mathematics education content courses that were designed to encourage and support more progressive beliefs about mathematics and the teaching of mathematics. Each of the preservice teachers had taken at least one mathematics education course directly from me with 11 of them having had me as their instructor for all three courses.

After completing a consent form in which all 63 agreed to be participants in the study, a survey on the beliefs held by preservice teachers about mathematics and the teaching of mathematics was given. To help reduce the possibility of my having any undue influence on student responses, two precautions were taken. First, the survey was administered by faculty members from the School of Education instead of by me or one of the other mathematics education professors with whom they may have previously had mathematics classes. Second, all 63 of the preservice teachers completed the survey at the same time during a seminar class conducted by Early Childhood faculty rather than during their regularly scheduled mathematics class.

Each preservice teacher was asked to complete an initial 50-question survey regarding beliefs about the nature of mathematics and about mathematics teaching. The survey consisted of statements about mathematics and mathematics teaching and then provided four possible Likert scale responses to the questions: Agree, Somewhat agree, Somewhat disagree, Disagree. A neutral response choice was purposefully omitted from the survey to require the preservice teachers to think more deeply about their beliefs and then make a selection that best reflected those beliefs. Each response was assigned a score of 1, 2, 3 or 4 with 1 indicating more traditional beliefs and 4 indicating more reform beliefs. Six students chose to indicate a more neutral response by circling both the somewhat agree and somewhat disagree responses to a single question. These students were awarded 2.5 points for these responses. No questions were left unanswered. Each participant's score was totaled and recorded. Student's scores ranged from a low of 137 to a high of 187 out of a possible 200 points. After scoring the initial survey, the preservice teachers were grouped into three categories based on their scores: the bottom 25%, the middle 50%, and the top 25%. Because I was looking at how newly developed beliefs of preservice teachers hold up during the first year of teaching, the 15 participants ranked in the top 25% were separated from the group. These preservice teachers were chosen because they appear to have the most progressive beliefs about mathematics and mathematics teaching based on their scores from the initial survey.

Once the 15 participants in the top 25% were identified, I examined the personal information sheets they had filled out on the day the survey was conducted. On this sheet they discussed their career plans and where they intended to seek employment after they graduated. The information sheets indicated that all 15 were interested in teaching in the fall (i.e., no one had plans to go directly to graduate school or look for alternative employment) so no one was eliminated at this point. I then looked to see the locations where these students were planning on seeking employment. In order to participate in the second phase of my study, it was my desire to select students who would be teaching within a 60-mile radius of the college campus. Eight of the fifteen participants planned to apply for jobs in counties within 60 miles of the campus while seven others planned to look for employment in the greater Atlanta area. For this reason, I randomly selected five of the eight who were planning on teaching in neighboring counties for the interview phase of the study. To select these students, I assigned each of them a number from 1 to 8 and then used the TI-84 plus calculator to randomly generate these 8 numbers, one at a time. The selection process was complete after 5 distinct numbers had been generated. These five students were notified of their selection to continue in the study via email. All five of the participants responded favorably to the email and agreed to participate in a series of observations and interviews, which took place during the fall of their first year of teaching. However, one of these participants was notified during the week of pre-planning that she would not be teaching mathematics and so would not be able to participate in this study. I then randomly selected another participant from the remaining eligible participants.

The five participants chosen for the study will be referred to as Kayleigh, Paige, Morgan, Ellen and Danielle. Four of the five participants were white females from either the Atlanta or central Georgia area. The fifth participant was an African American female from the central Georgia area. It is interesting to note that none of the male preservice teachers scored in the top 25%. Each of the selected participants was a first year elementary teacher during the fall of 2008. None of the participants had any prior teaching experience outside of their placements in the schools during their junior and senior years. Although it was my intention to select only students who would be teaching in the central Georgia area, after the selection process was complete, one of the students ended up taking a job in south Atlanta.

Kayleigh was a traditional college student from the Atlanta area. She was an outgoing person with a bubbly personality. Based both on her GPA and her performance within her mathematics education courses, Kayleigh was the strongest academically of all the participants. Her work in my mathematics and mathematics education courses could be described as outstanding. She was a very motivated learner and was enthusiastic about her career in teaching. Kayleigh had established herself as a leader within the cohort. Her leadership abilities made her a skilled organizer who often kept the entire cohort on task and apprised of the upcoming events and assignments. In addition, she was always willing to lead discussions both in small groups and with the entire class. She was hired to teach in the south Atlanta area at a large elementary school where she was one of ten second-grade teachers at her school.

Kayleigh accepted a position in a large public school that was a relatively new construction. The school was spotless and the halls were decorated with student work. The second grade classroom that I observed was large and well organized. Of particular interest to me was the bank of cubbies that housed bins of individual sets of mathematics manipulatives for each student. Kayleigh explained that the county had provided a classroom set for each teacher at the school. Students at this school were predominantly middle class with a few lower income students.

Danielle was also a traditional college student. She lived in the central Georgia area and planned to teach in this same area. Danielle was a soft-spoken person with a warm personality. Mathematics was her passion, and it did appear to be her strongest subject, although she was not as strong in her mathematics education classes as some of the others in the study. Her beliefs score, while in the top 25%, was not as high as three of the other participants. Danielle's first teaching job was in the central Georgia area in a large school system. Even though she preferred older students, she agreed to take a position teaching pre-kindergarten.

The student population at her school could be described as underpriveledged with 100% of the students receiving free or reduced price lunches. The building was older but in good condition. The classroom where my observation was conducted was relatively small and crowded with tables, chairs, bookshelves, computers, teacher desks, and books. Most of the items in the room appeared to be furniture and not supplies. It was later explained to me that it was difficult to get the supplies and technological support necessary for effective teaching at this particular school. While the classroom had several computers most were either broken or did not come with appropriate software. There were 20 prekindergarten students in the room with the teacher and paraprofessional teacher.

Paige was the only African American student in the study. Paige came from the central Georgia area and had always had a desire to teach there. She enjoyed working with underprivileged students and accepted a position to teach second grade in an inner city mathematics and science magnet school. Paige had a warm and sharing personality. She enjoyed mathematics and was an enthusiastic learner. On the beliefs survey, Paige had the lowest score of all of the selected participants, indicating that her beliefs may not have been as progressive as some of the others in the study.

Paige's school was a public school designated as the mathematics and science magnet for a relatively large county. The school was housed in an historic school building. Because of several additions, some portions of the school were much newer than others. The classroom I visited was located in the historic, older part of the building. It was a large room with high ceilings and hardwood floors. Because of the size of the room, there were many designated areas for different activities. Supplies, including mathematics manipulatives, were plentiful and clearly visible throughout the room. The teacher reported that her second grade students could best be described as middle to upper middle class with very supportive parents.

Morgan was a 22-year old traditional college student who can be described as the most energetic of the group. Morgan was not the top mathematics student within her cohort, but she was certainly the most enthusiastic learner. She was the most willing of all the cohort students to adopt new ways of thinking about mathematics and the teaching of mathematics. Because of her convictions about teaching mathematics in new ways, she convinced her placement teacher during student teaching to allow her to implement some major changes in the classroom. Her mathematical beliefs score was the highest of all 63 original participants, indicating that she had the most progressive beliefs of the entire group. In the fall of 2008, Morgan was teaching second grade in a large school within a large school system in central Georgia. Because of county restrictions, I was unable to visit Morgan's classroom to observe her teaching.

The final participant, Ellen, was a traditional college student from the central Georgia area. She can be described as a quiet and conscientious student. She enjoyed pleasing her teachers by doing good work. She was very reserved and needed to be prompted during class to share her ideas. However, once prompted, her ideas were always well thought out and relevant. Academically her work in mathematics was strong and, unlike many of her peers in early childhood education, Ellen had taken more advanced mathematics courses such as calculus. Her background in mathematics made her content knowledge more thorough than many of her peers. Ellen accepted a position teaching second grade at a small Catholic school in central Georgia.

The exterior of the building was not attractive and upon entering it was clear that the building was old and in disrepair. The second grade classroom where the observations were conducted was tiny but very neatly kept. The students were in uniforms and greeted me with a, "Good Morning Mrs. Shiver" as I entered the classroom. I later learned that most of the students came from middle class backgrounds. Ellen was observed using manipulatives during her math lessons but she later explained that there is little money available to supply her classroom and that she had to purchase the manipulatives herself.

Methods

The beliefs survey from which the participants were selected was initially used to gather information about the beliefs held by the participants in relation to the nature of mathematics and the teaching of mathematics. Statements for the survey were inspired by many sources and were written to reflect a more progressive view of mathematics and the teaching of mathematics. The six principles listed in the NCTM Principles and Standards (2000) were used as a guide in selecting the statements of interest, especially statements that reflected ideas about the teaching of mathematics. The principles describe our current understandings of the important features of high quality mathematics education. These descriptions lay a foundation for what we mean by best practices and allowed me to develop statements for the survey that best reflected these ideas.

The survey was purposefully constructed to have two or more statements reflecting the same or very closely related ideas. For example, the survey contained two statements reflecting the flexibility or rigidity of mathematics as well as three statements reflecting the idea of mathematics existing as a creation of human beings or as independent of human beings. This design helped ensure a more accurate picture of the beliefs held by the participants. Additionally, the participants were provided only four possible responses to the statements on the survey: agree, somewhat agree, somewhat disagree, and disagree. A neutral response was purposefully omitted to force the participants to reflect on the statement and to make a choice. Martin (2006) supports this structure stating that many survey respondents who would normally select the easy, neutral response which provides little information to the researcher, are capable of providing meaningful and accurate data when the neutral response is unavailable.

As suggested by research, the survey was first piloted with a group of 40 junior early childhood education majors to test it's reliability (Martin, 2006). After scoring the survey, apparent contradictions between similar statements were noted. Nine juniors who participated in the survey were randomly selected and met as a focus group to discuss their responses and to clarify the noted contradictions. Throughout the process Leatham's framework (2006) was used. As is suggested by the framework, the assumption was made that these preservice teachers questioned about all of the statements involved. One of the noted contradictions was between two statements regarding the necessity of drill and practice in mathematics instruction.

> Statement 13
>
> To be successful in mathematics students must practice procedures frequently until they become comfortable with the process.
>
> Statement 28:
>
> Assigning numerous practice problems to students is necessary to ensure that learning is taking place.

Both statements were intended to reflect a similar idea and were supposed to help determine the students' beliefs about the importance of drill and practice as a teaching technique within the mathematics classroom. While the statements were intended to be similar, the preservice teachers' responses did not reflect a common belief. The preservice teachers tended to agree with statement 13 but almost unanimously disagreed with statement 28. Employing Leatham's (2006) framework, I determined that the source of contradiction must come from either my misinterpretation of the students' responses or perhaps their misinterpretation of the posed statement instead of accepting that their beliefs were inconsistent. After a short discussion with the focus group, it was clear that students were interpreting problem 13 differently than had been intended and that their beliefs were not inconsistent. One student explained that to her the word "practice" in number 13 meant providing students with numerous opportunities to learn a new concept not just a one shot deal. She, as well as the other students in the group, felt that it was important to provide students with numerous and varied opportunities to learn a new concept so they agreed with this statement. However, in number 28 the word "practice" seemed to imply meaningless drill and practice problems on worksheets, which this group of students did not agree with.

After discussing their responses to these two statements as well as several other survey statements, I determined that a few of them had to be rewritten to better reflect their original intent. One of the statements that had to be rewritten was number 37, which originally read, "People who have difficulty with mathematics are unable to memorize facts and formulas." Students in the junior cohort tended to disagree with the statement suggesting that they held more progressive, less traditional beliefs about the nature of mathematics. However, when the focus group was questioned about this particular statement it became clear that these students actually agreed with the statement overall even though they responded disagree on the survey. What they were disagreeing with was the implication that the word "people" inferred that everyone who has difficulty in mathematics has difficulty with memorizing facts and formulas. While they agreed that this was the case for most people, they felt that they could find one or two exceptions; people who struggled with math in other ways, so they marked disagree on the survey. To better reflect their true beliefs about memorizing facts and formulas the question was reworded as follows, "people who struggle with mathematics generally have difficulty memorizing facts and formulas." Minor changes were made to three additional statements before giving the survey to the senior cohorts.

After corrections were made to the survey, it was administered to the senior cohort students and used as a means for separating them into three general groups: the bottom quartile, the middle fifty percent, and the top quartile. The initial survey was scored by assigning each of four possible Likert responses a value from one to four. The score from each of these items on the questionnaire was totaled. In addition, two sub-scores were separated from the total; one reflecting the beliefs held about the nature of mathematics and another reflecting the beliefs held about the teaching of mathematics. The total scores were then used to place students along a spectrum indicating their beliefs about mathematics and the teaching of mathematics. Students with high scores indicated those who see mathematics as fluid, logical and consistent and who are more focused on the teaching methods described in the NCTM standards such as hands-on, inquiry-based learning and discovery. Low scores indicated students who see mathematics more as a set of rules that are rigid and unchanging and whose pedagogical preferences lean more toward traditional teaching methods such as lecture, memorization and drill and practice.

The survey was then used to select students for the second phase of research. The separation of students into three groups allowed students with the most progressive beliefs to be placed into the top twenty-five percent. This allowed for a reduction in the number of eligible participants for the study from 63 to 15. The fifteen highest scoring students were placed in the top group from which the study participants were selected. The high scores indicated that these fifteen students, upon completing their mathematics course work in college, had adopted a less traditional, more reform oriented perspective on mathematics and the teaching of mathematics as described in the NCTM Principles and Standards (2000). Five preservice elementary teachers were selected from this group.

Initial interviews were conducted with the five selected participants prior to the beginning of their first year of teaching. Questions and responses from the initial survey were used to help design a protocol for the interviews. With Leatham's framework (2006) in mind, the initial interview was designed purposefully to clarify and expand on responses from the initial questionnaire. Responses on the survey that appeared to be in contradiction with one another were a major focus of the interview. This clarification process helped to ensure that the beliefs the participants held prior to entering their first year of teaching were more accurately reflected. Interviews were conducted on the college campus in the mathematics department conference room and each lasted from 30 to 60 minutes. All of the interviews were digitally recorded, transcribed and coded based on emergent themes. Because one of the initially selected participants had to withdraw from the study and a replacement was selected at a later date, no initial interview was conducted with this new teacher as she had already begun her first year of teaching.

Further interview data were collected from the five selected participants during their first semester of teaching. Each participant asked her principal to sign a form granting permission for three observations and follow-up interviews to occur at her school. After receiving permission, observation times were scheduled. Even though I was not directly interested in how teacher's beliefs and actions correspond, I thought that observing the teachers within their own classrooms would help me conduct a deeper, more meaningful interview (Mewborn, 1999). While it was initially my intent to visit each participant's classroom at least three times during her first semester of teaching and observe her during a mathematics lesson, because of unforeseen problems my methods had to be adjusted to accommodate each participant's particular situation.

My observations began at Danielle's school in a pre-kindergarten classroom. I chose a seat at the back of the classroom to minimize the disruption of having a visitor in the classroom. I took notes on a legal pad to record the conversations and activities that occurred during the lesson. The lesson lasted approximately 50 minutes. After the lesson, students were taken to the playground for recess. Danielle and I stood off to the side of the playground where I interviewed her. The interview lasted approximately 30 minutes and consisted mainly of questions about what I had just observed. A few pre-planned questions were also asked at this point. It had been my intention to use a tape recorder to capture the interview but because of the noise level and environment I decided to record Danielle's responses in writing on the legal pad instead.

My second observation was within the same school system and was intended to be with Morgan however, once I arrived at the school the principal informed me that the board of education for the county had recently passed a ruling prohibiting research from being conducted within their schools. Because of this decision, observations would not be possible with Morgan and they would no longer be possible with Danielle. So instead of observing these teachers as planned, we set up times to complete two interviews on the the college campus.

Two successful observations and interviews were completed with Paige, Ellen and Kayleigh, one in September and one in October. With each of the participants, I observed a math lesson that lasted approximately one hour and then spent about 30 minutes interviewing them. I asked questions about what I had observed during the math lesson along with some general pre-planned questions. Again, because of the varying environments for interviews I abandoned the tape recorder and took notes using a pen and legal pad.

The first interview with the participants I was unable to observe, Morgan and Danielle, was held on the college campus in October. By inviting two teachers to discuss their beliefs about mathematics and the teaching of mathematics at the same time, I found the discourse to be much richer than in my one-on-one interviews held at the elementary schools with the other three participants. The two teachers involved seemed to be more relaxed and open in their comments than the others had previously been. During this session I posed some pre-planned questions and allowed them to respond and discuss freely. As the discussion progressed, the teachers spoke freely about their beliefs, especially their beliefs about the best ways to teach mathematics. They also openly discussed the challenges they faced on a regular basis. This meeting lasted approximately two hours.

Because of the success of this session, I decided to abandon the third observations/interviews for Paige, Kayleigh and Ellen and instead invite all five of the teachers to the college campus to discuss their beliefs as a group. This focus group met in early November. Questions for the interview were a combination of predetermined questions that all participants were asked and those that emerged during conversations. This discussion again proved to be rich with comments from one student inviting comments from another. The focus group discussion lasted approximately three hours. All of the interviews conducted during the fall were recorded in writing on legal pads. Later they were typed into a word document and coded based on the themes that were determined using the sensible system framework.

Finally, at the completion of their first semester of teaching, the five teachers were asked to complete the original questionnaire that they had taken the previous spring. The questionnaire was scored using the same procedure as was used for the original survey. The responses to the statements on the survey were compared with those made previously to determine any shift in beliefs. Apparent changes were noted and contradictions were identified.

Analysis

Keith Leatham's (2006) Sensible Systems of Beliefs framework was employed during the analysis phase of this research study. Within this framework, one assumes that beliefs and knowledge can be viewed as complementary subsets of a larger set of beliefs. Leatham (2006) defined these two levels of beliefs as "things we more than believe," which he referred to as knowledge and "things we just believe," which he referred to as beliefs. Because both are considered subsets of beliefs, no distinction was made between them when analyzing the data thus allowing me to examine knowing and believing with the same criteria.

Analyzing the data was an ongoing process that occurred throughout the data collection process beginning after the administration of the initial survey. Throughout the entire process, I wrote informal notes suggesting emergent themes and observations that could be followed up with further questions during future interviews.

Once the study was completed, the transcribed data from each of the sessions was carefully read, divided into meaningful analytical units, and then coded. As is suggested in Taylor's (2003) guide to *Analyzing Qualitative Data*, I used both predetermined and emergent themes during the coding process. The coding system used involved first dividing the data into two predetermined main categories- beliefs about the teaching of mathematics and beliefs about the nature of mathematics. As I was constructing statements for the initial survey, the statements began to naturally fall into one of the two categories. I decided to continue with this natural separation when analyzing the data. Color-coding was used to help quickly identify each of the two meaningful strands. Nature of mathematics statements were colored blue, and pedagogical statements were colored yellow. Each of these categories was then separated into subcategories, which reflected both predetermined and emergent themes. Coded themes found under the heading of nature of mathematics included mathematics as a human creation, mathematics as flexible and changing, mathematics as attainable by all, mathematics as problem solving, and mathematics as a set of integrated ideas. Sub-categories under the heading of pedagogical beliefs included autonomy, student/teacher centered instruction, varying mathematical approaches, student learning, reflection, and reform methods. See Table 1 below for a detailed list of codes.

Table 1

Coding Scheme

Category	**Sub-category**	**Description**
Nature of Mathematics		
	Human Creation (HC)	beliefs as to whether or not mathematical ideas exist independently or are a creation of human beings
	Flexible and Changing (F)	beliefs as to the flexibility or rigidity of mathematical ideas.
	Attainability (AS)	beliefs about the attainability of mathematical concepts by students.
	Problem Solving (PS)	beliefs about the purpose of mathematics including ideas about reasoning and conceptual understanding.
	Integrated Ideas (II)	beliefs with regard to the integrated nature of mathematical concepts.
Pedagogical		
	Autonomy (A)	beliefs indicating whether or not they seek verification from an outside authority.
	Student/teacher centered instruction (SC or TC)	beliefs about the benefits or pitfalls of teacher or student centered instruction.
	Varying mathematical approaches (VA)	beliefs indicating a recognition of either a procedural approach to teaching or a more conceptual approach involving more open ended investigations.
	Student learning (SL)	beliefs on how students best learn mathematics including student engagement, questioning, and level of understanding.
	Reflection (M - mirror)	beliefs regarding the importance of reflection within the mathematics classroom.
	Reform Methods (RM)	beliefs about the importance of best practices within the mathematics classroom including the use of manipulatives, group work, lesson types, etc.

In addition to placing each statement into the appropriate category and sub-category, it became apparent during the process that statements needed to be coded to indicate whether or not they addressed more traditional or more progressive views and whether or not the teachers were expressing a positive or negative view toward the stated beliefs. The letters T and P were used to indicate whether each statement reflected more progressive or more traditional ideas about mathematics and/or the teaching of mathematics as well as a plus sign (+) or a minus sign (-) indicating, respectively, either a positive or a negative attitude toward the stated belief. Also, if there was a noticeable shift from a prior belief the coding was underlined indicating that some change had taken place. Because of the difficulty in quantifying the change, there was no code used to indicate the magnitude of the shift in beliefs. Instead, each statement was examined independently to determine whether or not any meaningful change had occurred.

Finally, a star was used to indicate whether or not students commented on any external influence that posed either a challenge or constraint to their beliefs about mathematics or the teaching of mathematics. Next to the star, a word was written identifying the challenge or constraint mentioned in the statement. Once the statement was coded with a star, if the first year teacher described being resistant to, defying or manipulating the challenge/constraint to support her own beliefs about mathematics then a circle was placed around the star. If the teacher commented that she behaved in a way as to follow the perceived constraint but against her beliefs then the star was underlined. If the teacher suggested going along with the challenge/constraint because of other beliefs that she thought were more important than what she believed about mathematics and mathematics instruction, then the star was boxed.

Example of a coded statement.

The following statement was made by Paige and demonstrates how I coded the transcribed data. When Paige was asked if she still believed that all students can learn meaningful mathematics as she had indicated earlier on the initial survey, she responded:

> I still believe that all children are capable of learning mathematics; however, some choose not to apply themselves. You can provide them with a rich environment to learn math in, good instruction, well-designed lessons, but unless they want to engage in it and learn, you can't make them.

This statement was coded in the following way:

<u>Blue , AS, P –</u>
☆ Student attitude

This coding indicated that Paige's statement was about the nature of mathematics and involved her belief about a student's ability to learn meaningful mathematics. Because her statement focused on the more progressive belief that all students can learn meaningful mathematics, it was coded with a P. However, because she indicated that there were some children who were not able to learn meaningful mathematics, a negative sign was included to indicate a lack of support for the stated belief. The code used was also underlined to show that a possible shift in a previously stated belief had occurred.

The star followed by the statement, "student attitude" indicated that the first year teacher had identified a challenge to her beliefs about student learning. She pointed out that a student's attitude about whether or not to engage in the mathematics being taught had an effect on their ability to learn mathematics.

Subjectivities Statement

I have spent half of my lifetime teaching mathematics to students ranging in age from 12 to 60, and during these years I have noticed that the vast majority of these students enter my classroom with an already firmly developed dislike or even fear of mathematics. Even more alarming is that many of these students see mathematics as a disconnected series of rigid rules and procedures that must be memorized and applied to irrelevant problems often found in textbooks. Throughout my years of teaching, I have spent countless hours trying to change unproductive beliefs about mathematics and to help students develop a lasting appreciation for the nature of mathematics.

As a mathematics educator, I am always interested in the effect that teaching has on the formation of beliefs about mathematics. Because of my deep interest, I had to be particularly careful about my own subjectivities. While my passion for this research can be seen as positive in many respects, it is also here where I had to be keenly aware of how I might distort or misinterpret data. Because I was working with preservice teachers who were formerly my students and as it was my desire to see that my teaching had affected the beliefs of these teachers, I had to ensure that I did not let these desires sway the research process in any way. In addition, I had to be aware that students will not always share my more progressive beliefs about mathematics. I had to be careful throughout the process not to judge those students who held beliefs that were different from mine or different from those presented throughout their mathematics education courses.

As Alan Peshkin (1988) suggested, it was important for me to develop a system for monitoring my subjectivities throughout the research process. To help minimize my subjectivities, I followed up the initial questionnaire and each of the observations with an interview. These interviews helped me clarify the participants' written responses on the questionnaire and ensured that my interpretation of their responses was as accurate as possible. Interviews held after the observations were used to discuss actions taken by the teacher during her lesson as well as other ideas about mathematics. By using Keith Leatham's framework (2006) and assuming teachers to be rational beings whose actions within the classroom are sensible, these interviews allowed me to investigate the connection between her actions and beliefs, thus avoiding the pitfall of assuming that any perceived difference is simply a disconnect between the two. By allowing the teachers to explain the motivation behind their actions, the influence of my preconceived ideas about beliefs and teaching practice was minimized. In addition, carefully designed coding schemes for analyzing both written and interview responses were used and once again helped me minimize my subjectivities when analyzing data.

CHAPTER 4

Results

The goal of this study was to better understand the flexible construct of beliefs and their stability in the first year of teaching. In addition, I hoped that this work could help identify some of challenges that most affected the beliefs of these young teachers. The teachers chosen for the study had completed an intensive, field-based college program and were ready to enter the classroom with strong beliefs about mathematics and the teaching of mathematics that were consistent with current reform efforts. During this study, I examined how these beliefs were challenged and how they changed when exposed to the various situations and decisions that arise during the first year of teaching. I also examined and identified the challenges and constraints faced by these first year teachers and how they impacted the beliefs held by these teachers.

Survey Results

Students' cumulative scores on the initial survey ranged from 137 to 187 out of a possible range of 50 to 200 points. Both the mean and median cumulative scores were approximately 165. Scores were broken down into two subscales- the nature of mathematics and the teaching of mathematics. Students' scores relating to the nature of mathematics ranged from 56 to 86 out of a possible range of 24 to 96. Students' scores relating to the teaching of mathematics ranged from 73 to 103 out of a possible 26 to 104. Higher scores on each of the sections indicated more progressive beliefs with lower scores indicating more traditional beliefs. Results from the survey showed that overall the preservice teachers' beliefs were more progressive and in line with current understandings about best practices. Research has shown that beliefs about the nature of mathematics tend to be slightly more traditional than pedagogical beliefs and the sub-scores obtained in this study seem to support that claim. One explanation for this difference is provided by Yates (2006) who explained that often times teachers beliefs about the nature of mathematics appear to be unrelated to their beliefs about the teaching and learning of mathematics. This may be due to the fact that preservice teachers have been given little opportunity to reflect on ideas surrounding the nature of mathematics but great opportunity to examine their views about the teaching of mathematics which is the case for the preservice teachers in this study.

Because the initial survey was used to narrow down the pool from 63 participants to only 5 participants who exhibited the most progressive beliefs, the remainder of the discussion will focus only on the five chosen. These 5 preservice teachers' cumulative scores on the initial survey were in the top 25% of the group and can be seen below:

Table 2

Participant Data – Initial Survey

Name	Nature of Mathematics Score (96 points possible)	Teaching of Mathematics Score (104 points possible)	Cumulative Score (200 points possible)
Kayleigh	81	100	181
Danielle	81	93	174
Paige	85	86	171
Morgan	84	101	185
Ellen	86.5	91	177.5

Both their overall score and the separate survey data revealed that these 5 preservice teachers held progressive beliefs about both the nature of mathematics and the teaching of mathematics.

I looked very closely at the groups of similar statements that showed conflicting responses. I also looked for statements that had varied responses across the chosen participants. For example, while all 5 teachers disagreed that "truly understanding mathematics requires special abilities that only some people possess," there were mixed responses to the similar statement that, "working hard will increase your ability to understand mathematics." On the second statement, 1 of the preservice teachers agreed with that statement, 1 somewhat agreed with it, 2 somewhat disagreed with it and 1 completely disagreed with the statement. Because of their conflicting responses, all 5 were questioned about this statement during individual interviews and their responses will be discussed later.

In evaluating the data from these interviews I tried to separate the qualitative data into the two beliefs categories used in the survey- Nature of Mathematics and Teaching of Mathematics. However, as the analysis progressed, it became clear that there would inevitably be some overlap between categories. Often students' comments and discussions were complex and involved more than one belief about mathematics and the teaching of mathematics at a time. For example, a discussion about student abilities to learn mathematics naturally involved a discussion about teaching techniques and the use of manipulatives. To further analyze their beliefs, each of these main categories was separated into subcategories. The nature of mathematics category was separated into areas looking at mathematics as created or discovered, the rigidity of mathematics, attainability, the purpose of mathematics, and the integrated nature of mathematics. The teaching of mathematics category was separated into autonomy, student/teacher centered instruction, mathematical approaches, student learning, importance of reflection, and reform methods. See Table 1 for a summary of these subcategoriesI have separated the following discussion based on the two general areas and their sub-categories; however, discussions and cited comments in one area will sometimes reflect a belief from another area as well.

The was administered a second time to provide additional data about the changes in beliefs. The results are summarized in the table below.

Table 3

Participant Data – Final Survey

Name	**Nature of Mathematics Score (96 points possible)**	**Teaching of Mathematics Score (104 points possible)**	**Cumulative Score (200 points possible)**
Kayleigh	80	94	174
Danielle	85	98	173
Paige	75	85	160
Morgan	87	95	182
Ellen	89	102	191

The cumulative scores revealed that all 5 preservice teachers still held their progressive beliefs. The subscale for the teaching of mathematics indicated that all 5 still held their progressive beliefs and the second subscale showed that 4 of the 5 continued to hold strong progressive beliefs about the nature of mathematics. Only one student, Paige, had a noticeable drop in her score relating to the nature of mathematics. The questions that saw the greatest decrease dealt with the rigidity of mathematics and a belief that mathematics is unchanging. However, her overall score still indicated that she continued to hold progressive beliefs although not as strongly as before.

Nature of Mathematics

Historically, there has been disagreement about what is meant by the nature of mathematics. In this study, van de Walle's (2007) definition of mathematics as the "science of pattern and order" was used to describe more progressive views about the nature of mathematics and its components. In contrast, the more traditional view of the nature of mathematics was seen as consisting primarily of views of mathematics as formulas, algorithms, theorems and solutions (Raymond, 1997).

During the interview process, the teachers rarely commented on beliefs about the nature of mathematics. Only when asked a direct question about the nature of mathematics was the topic ever thoroughly discussed. These young teachers admitted that, while they spent a great deal of time reflecting on their teaching practice, they rarely reflected on ideas regarding the nature of mathematics. Given this lack of conscious thought about the nature of mathematics, it was not surprising that the majority of their comments reflected their beliefs about how to teach mathematics and not about the nature of mathematics.

Rigidity of mathematics.

In regard to the nature of mathematics, the initial survey results showed that overall, all of the teachers held progressive beliefs. However, it also showed that not every aspect of their beliefs was progressive. For example, three of the five teachers initially viewed mathematics as a rather static body of knowledge while only two saw it as a more flexible, changing body of knowledge. When questioned about their views, the teachers who viewed mathematics as static supported their view by indicating that the mathematics content found at the elementary level had been basically the same for years.

As one student stated, "adding is adding and will always be adding." They thought that the changes that had occurred in mathematics and in the mathematics curriculum over time were always pedagogical changes that only affected the way in which the material was presented and not the mathematics itself. While all of the teachers in the study held progressive views about the teaching of mathematics, stating strong beliefs that the best way for students to learn was to engage them in meaningful mathematical experiences where they could develop conceptual understanding, they still perceived the mathematics itself as mainly a stagnant body of knowledge. With regard to an elementary mathematics curriculum and the experiences of these new elementary teachers, it is not surprising that three of the teachers held a view of mathematics as an unchanging body of information. Elementary mathematics concepts have been virtually unchanged for hundreds of years so it is not unexpected that they have formed this belief and without exposure to higher levels of mathematics it is doubtful that this belief will change. In fact, their experiences in the first few months of teaching seemed only to strengthen this belief. In the final survey, four of the five teachers indicated that they now held this belief about mathematics.

Integrated topics.

Even though this group of teachers viewed mathematics as static, the initial survey indicated that they viewed the concepts in mathematics as integrated and not as a set of disjoint or unrelated topics. However, as suggested by Leatham's (2006) Sensible System Framework, I looked at the survey data more carefully and discussed this belief with individual teachers. Through these discussions, I found that each teacher's interpretation of what was meant by integrated topics varied greatly from teacher to the next. Some of the teachers indicated that they believed that all mathematics was interrelated while others indicated that they believed only certain parts of mathematics were interrelated but that other parts were completely separate. For example, these teachers could see a clear connection between telling time and understanding fractions but thought that topics like learning geometric shapes had little to do with other mathematics topics outside of geometry. The implication from most of this group was that they believed that some mathematics was interrelated but not all of it. By the end of the first semester, however, the final survey indicated that all five of the teachers had adopted a much stronger view of mathematics as a set of interrelated topics.

Attainability.

Based on the final survey and discussions held throughout the first semester of teaching, the only area where there was any noticeable, negative shift in beliefs seemed to be related to students' abilities to learn mathematics. On the initial survey, all five of the teachers indicated a strong belief that all students can learn meaningful mathematics. After the first semester of teaching they were asked whether or not they still believed this to be true. All five teachers indicated that their belief about all students being able to learn important mathematics still held. However, it was clear from our discussions that some of the teachers' beliefs about student learning might not be as strong as they previously were. Their responses to the question now came with clarification. They continued to state their belief that all students could learn important mathematics, but their experiences in the classroom had challenged them to examine this belief and to make sense of what they were experiencing with their students.

Despite their best efforts in the classroom, each of the teachers expressed frustration with individual students who were not progressing as the teachers felt they should. The teachers seemed to be searching for explanations for the students' inability to master the content being taught. Some of the reasons given by the teachers for the noted insufficient progress by their students were weak backgrounds and unsupportive home environments, misbehavior, inattentiveness, and an overall lack of motivation by the students. Paige captured the sentiment stated by several teachers. She pointed out that she still believed that, "All students were capable of learning mathematics but that some students choose not to apply themselves." She further explained that, "As a teacher you can provide them with a rich environment, good instruction, well designed lessons but unless they engage in it, you can't make them learn." These young teachers also expressed a concern that not every child can learn at the same pace as is often proposed by the mandated curriculum or the county guidelines. The final survey reflected that the teachers still believed that all students could learn mathematics but the interviews and discussions reflected a weaker belief or perhaps a belief with qualifications.

Conceptual Understanding and Problem Solving.

Developing conceptual understanding in their students was of extreme importance to this group of teachers and appeared to be one of the most strongly held beliefs. Both in the survey and through observations and discussions it was apparent that all of the teachers valued the development of conceptual understanding in their students over procedural understanding. For example, during one observation with Ellen, it was clear that she valued allowing students to invent and then explain their own strategies for solving problems. She explained that she thought that this process was imperative to their complete understanding of a concept. She was not alone in her views. All five teachers declared the importance of developing conceptual understanding in their students and had their students engage in creative problem solving. Kayleigh described how her efforts to teach conceptually translated from her classroom into the classrooms of other teachers at her school.

> We have only recently begun collaborative planning and none of the teachers understand what that means or how to promote it so I have become the team leader in terms of planning lessons. I know what is best when it comes to teaching my students math and so far what I am doing has been effective so now many of the teachers are coming to me for advice and ideas. They are starting to see the difference in teaching the concept and not the book.

Like Kayleigh, each of the teachers held strong beliefs about the importance of developing ideas conceptually and equally strong beliefs about the methods to be used to achieve this. The experiences within the classroom did not appear to have any negative effect on this belief.

Discovered or Created.

The teachers in this study were asked about their beliefs as to whether mathematical ideas exist independently of humans or are a creation of humans. Three statements on the survey reflected these ideas. The response on the first statement, "Mathematics is created by humans and is used to describe various phenomena," showed that this group of teachers clearly did not believe that mathematics was a human invention. Four of the five teachers disagreed with this statement while one somewhat agreed with it. All five agreed with the second statement, "Mathematical content is fixed and predetermined, as it is dictated by the ideas already present in the physical world." These two statements seem to reflect a belief among these teachers that mathematics exists independent of human beings. However, the third statement, “mathematical ideas exist independently of human ability to discover them,” appeared to contradict the responses on the previous two statements with four of the five teachers disagreeing with this statement.

As Leatham (2006) suggested, this apparent contradiction in beliefs required me to form a deeper understanding of the teachers’ beliefs and to reconsider what I was inferring about their beliefs. When questioned about their beliefs about mathematics as existing independently of humans versus mathematics as being created by humans they admitted that this was not something that they had previously considered. Even during the interviews, the teachers paused for several seconds to reflect on their responses to the survey before answering. After reflecting for up to a minute, each one responded in a similar fashion to Danielle who stated, “ I feel like math exists but maybe humans came up with methods to figure it out. They [humans] came up with the methods to figure out math that is already there.” All of the teachers shared a belief that mathematics is discovered not created by humans. They thought that mathematics exists independent of human beings but that once discovered, it is the humans who formalize it and create a meaningful symbol system to represent it. With this interpretation, the responses to the third statement that appeared to contradict the other two statements actually did not. The teachers explained that they disagreed with this statement because while they did think that mathematical ideas were “out there” waiting to be discovered, they also believed that human beings were necessary to discover and make sense of these ideas. They thought that this statement was saying that humans were not necessary in the process of developing mathematics, which is what they did not agree with.

On the initial survey, the teacher's beliefs' about mathematics being discovered and not created implied to me that they also believed that mathematics is absolute and unchanging. And in fact, their agreement with the statement, "One of the best things about mathematics is that its content is unchanging" seemed to indicate that this was the case. While the vast majority of their responses to the 50 statements on the survey indicated very progressive views about mathematics and the teaching of mathematics, this was one area in which the teachers held what I would consider more traditional beliefs about mathematics. Their experiences within the first few months of teaching appeared to have little or no effect on this belief as the final survey showed that the teachers still believed that mathematics was discovered, not created, and that it was unchanging.

Pedagogical Beliefs

Before I begin my discussion on the pedagogical beliefs held by the teachers of this study, I must first define what I mean by pedagogy, beliefs and more specifically pedagogical beliefs. One of the most common definitions of pedagogy is that it is the art, science or practice of teaching. While this definition is sufficient for many daily conversations, it does seem to be a bit general for my analysis here. Instead, I adopted Alexander's (2000) definition of pedagogy for this study. Alexander (2000) described pedagogy as the performance of teaching together with the beliefs, theories, policies and constraints that inform and shape it.

For a working definition of beliefs, I adopted Leatham's (2006) definition in which no distinction is made between what we refer to as beliefs and what we refer to as knowledge. Leatham (2006) explained that, "beliefs and knowledge can be viewed as complementary sub-sets of the set of things we believe." (p. 92) Using this understanding, I defined beliefs as those things that we either know or believe to be true. Combining this definition with the definition of pedagogy provided me with my definition of pedagogical beliefs. For the purposes of this study, I defined pedagogical beliefs to be those beliefs that inform and shape the practice of teaching. The pedagogical beliefs that were the primary focus of this study were those that were directly related to the teaching of mathematics. However, other, non mathematical, beliefs were mentioned by the teachers and will be presented in the following discussion as well.

Autonomy.

It was clear from both the observations and interviews that all of the teachers in this study held a constructivist philosophy in regard to student learning and in turn this philosophy was reflected in their beliefs about the teaching of mathematics. While all 5 teachers asserted a belief that students must develop their own understanding of mathematical concepts, they varied on how much assistance/guidance they thought was necessary for this development. In relation to student autonomy, each of the teachers was either observed allowing students to present, justify, and reflect on the viability of their own work or, if not observed, they discussed its importance during the interviews and focus groups. A common belief that students needed to develop the skills necessary to evaluate their own work and the work of their peers was evident. Ellen described her belief in the following way:

> I think it is important for students to be allowed to openly discuss ideas. They need to be able to bounce ideas off one another. Often times students will help each other understand something and they don't have to ask me. If they weren't allowed to talk then I would have to answer all questions. This way they trust their own answers.

There was a clear belief that students, both individually and collectively, needed to become autonomous within their classroom. Students were encouraged to verify their work without the constant confirmation of the teacher or a textbook.

While all five teachers thought it was important that their students become autonomous and not be dependent on the teacher for solutions or verification of their work, this was not the case for the teachers themselves. On the initial survey, two of the five teachers agreed with the statement, "As a teacher, it is important to check all of your solutions with the textbook to be sure they are accurate." This response indicated that they believed that it was necessary to look for outside verification when solving mathematics problems. When questioned about their response they indicated that it made them feel better to know that their solution matched the one given in the textbook. Kayleigh explained her belief as follows:

> Kayleigh: It is always good to do a second check. I mean, I guess if I were working with my students or giving homework problems I would do it but then I would check the textbook for a piece of reassurance. I know that it can be wrong.
>
> Researcher: What would you do if you looked in the back of the book and your answer didn't match?
>
> Kayleigh: I would probably think it is wrong.
>
> Researcher: (Laughs) You mean the textbook.
>
> Kayleigh: Yeah. I mean I would work it again but … I mean I wouldn't hold it as the … you know…
>
> Researcher: So in the end would you rely on yourself more or the textbook?
>
> Kayleigh: Myself more. I think the textbook would just be a second check. Kind of right before… Even when I was in school and we were assigned problems and there are answers in the back you can check when you are done I wasn't prone to go to the back first. You know, I liked to work the problems then just check it to reassure myself that it was right.

> Researcher: Again as a teacher you think that it is not a bad idea?
>
> Kayleigh: It is not a bad idea to refer to it but I wouldn't think that these are for sure the answers and there is nothing swaying from that.

While two of the teachers indicated some need for outside verification, they both stated that when conflicting results were noted they would choose their solution over the textbook. A slight change was noted in this belief from the initial survey to the final survey. For three of the teachers this belief seemed to be strengthened in the first semester of teaching. A possible explanation for the change might come from the isolation and lack of peer support that these young teachers experienced. Instead of looking to their peers for validation, they looked to their textbooks. On the final survey three of the five teachers indicated a need to check solutions with the textbook.

Varying Approaches and Reform Methods.

Not only was the belief about teaching conceptually strong in the studies participants but also the belief about the best ways to accomplish it. The use of manipulatives in the teaching of mathematics conceptually appeared to be important to all five of the teachers and was an area where they refused to compromise. Each one indicated numerous times her belief that the use of manipulatives was important in developing student understanding of mathematics concepts at the elementary level. Four of the five teachers appeared to value the exploration of ideas by allowing students to problem solve on their own with minimal guidance. These teachers often encouraged students to directly model their solutions with manipulatives. Morgan explains:

> I find that letting students explore ideas is the best way for them to learn. Many times I just put manipulatives in front of them and let them explore with very little guidance. Once they begin to discover certain things, I can start asking them leading questions and before you know it they have it all figured out.

While most of the teachers encouraged exploration in the manner described by Morgan, Paige appreciated a more controlled environment. She too valued the use of manipulatives, but her lessons were much more leading than her peers' lessons as she guided her class through activities to a predetermined result. For example, when teaching the concept of time to the nearest quarter of an hour, Paige gave all students a clock to model different times of the day on. Unlike her peers who seemed to appreciate more open exploration, Paige then proceeded to explain how to determine the time of day, model the time on her clock, and then ask the students to model the time as she had done. Students were then given the opportunity to model times without Paige modeling it first but as soon as students modeled the time, she would correct those who were wrong and ask others to show how to correctly model the time. This guided instruction was used in both of Paige's observed lessons. Students were not given the opportunity to explore concepts independent of the teacher in either of the lessons.

The teachers' resolve in the use of manipulatives to teach conceptually was clear. Even when manipulatives were not available through the schools the teachers found ways to produce or acquire them. This commitment was best demonstrated by Ellen who had no manipulatives available to her and had to purchase her own. She explained:

> I always teach things hands-on and with manipulatives. I do, however, try to stay on pace in the (required) workbook with the other 2nd grade teacher. The only problem is that she teaches directly from the text and I try to teach things more conceptually and only use the workbook when I have to.

She further explained that she thought that it would be difficult if not impossible to teach mathematical concepts without something concrete. The other teachers in this study also indicated great success in fostering student understanding through the use of manipulatives. This success with their students seemed to justify their beliefs about the importance of manipulatives and strengthen their resolve in their continued use.

Student Centered Teaching.

A student-centered approach to teaching was used by all five of the teachers. The teachers often based their instructional decisions on their students needs and allowed their students to take more control of their own learning. By the final survey there was a clear consensus that this group continued to believe that students must take ownership of their learning and they must be actively involved in mathematics class in order to understand the mathematics that they are learning. The importance of active learning was noted throughout my observations at the schools. During one observation, I noticed that Kayleigh had asked all the girls in the class to assist with calendar time, which involved several short tasks such as determining the date. Each task was followed by a series of questions such as, "in how many days will it be Friday?" Kayleigh explained her reasons for involving the students:

> Researcher: I noticed that you had all of the girls in your classroom help with calendar time today.
>
> Kayleigh: Yes. I used to do the calendar all by myself but I noticed that the students were getting bored just sitting there watching me so I decided to let them do it instead. I alternate between the girls and the boys and give them different tasks each time. I make them explain how they got their answer each time. They can't just give me a one-word solution. It seems to be working really well. The kids are doing a really good job explaining things and it seems to boost their confidence levels both with math and in speaking in front of others.

Like Kayleigh, the decisions about organization, content, pace, and presentations made by all 5 of the teachers in their mathematics classrooms were largely determined by the students' needs and the teachers' perceptions of their students. For example, Morgan explained one way that she had to consider her students' needs when making instructional decisions, "I have actually found that the slower kids get bored more easily, so I have to keep them busy and interacting with something. That is why I have found the centers to be so effective." The belief about the importance of considering students' understanding and needs was evident from both the initial and final survey in which all 5 teachers strongly agreed that "It is important to consider what children know and understand when making decisions about mathematics instruction."

Student Learning.

Student learning tended to be the greatest influence on the teachers preparation and planning. Student learning was mentioned frequently by all of the teachers and tended to be at the center of most teaching decisions. Their beliefs about how students learn best seemed to be the driving force behind most of their instructional decisions. Kayleigh describes her process for planning a lesson:

> When planning a lesson I mostly think about the kids and what they are interested in. My pacing for the lesson is dictated by the students. I usually give some type of a pre-test which shows what the kids already know so sometimes I can go faster.

Specific techniques for improving student learning were often mentioned. Techniques such as allowing students to discover mathematics concepts in peer groups and to explain their solutions to the groups were used often by these teachers. The importance of students learning through peer interactions appeared to be a strongly held belief. On both the initial and final survey, all five of the teachers agreed that, "Students can best understand mathematics by discovering its ideas on their own or in peer groups." Another technique that this group believed to be of great importance was the use of questioning.

All of the teachers indicated a need to ask questions to determine a student's knowledge of a mathematical concept. Danielle summarizes her belief below:

> I try to ask a lot of questions that make them think. I am really amazed at some of the answers and ideas I get when they have a chance to talk. I sometimes find myself shocked at how much they know. Just yesterday a student told me something and I looked at him and said, "You are so smart." These kids know a lot more than they are given credit for.

Questioning was an important part of the lessons planned by the teachers. Each one indicated a need for using good questions and thought that this was the only way to really determine what a child knows. All expressed concerns that written assessments were not sufficient for truly understanding what students know. This belief held by the teachers only seemed to be strengthened throughout the first semester of teaching.

Problem Solving.

During a lesson in which students were using M&M candies to construct pictographs and bar graphs, Ellen asked her students to answer a series of "more" and "less" questions about the bar graph. Once students had completed the activity, Ellen had students share their solutions. One of the problems asked whether a student had more yellow M&Ms or more green M&Ms. It was followed by the question, "How many more?" The first student volunteer indicated that he had more greens than yellows and that he subtracted to find out how many more. Several students were excited by this suggestion to subtract because they had not considered this approach. Another student indicated that she had more yellows and went to the board to draw her solution as shown in figure 1.

$Y \leftrightarrow G$
$Y \leftrightarrow G$
$Y \leftrightarrow G$
$Y \leftrightarrow G$
Y

Figure 1:

Comparing Colors

This student used the comparison model to visually represent her ideas to the group. When asked Ellen explained that she had not "taught" either of these methods for solving the problems but that the students had come up with these strategies on their own. Ellen further explained why she believed it is important to allow students to share their strategies for solving problems with other students:

> By letting students share their methods for solving problems it helps other students to see different ways to look at a single problem. A new way of looking at something helps the idea click with other students. That's why I chose to have one person show the solution using subtraction and the other show it more visually.

This belief about the importance of problem solving was also supported on both the initial and final surveys. All of the teachers agreed with the statement, "Teachers should encourage students to improvise mathematical approaches in solving problems." The first few months of teaching appeared to have no negative impact on this belief.

Constraints

Not surprisingly, new teachers, including the ones in this study, are faced with many expected and unexpected challenges in their first year of teaching. Zeichner (1980) cited several possible challenges to first year teachers, including teachers and others with administrative power over the new teachers, the environment of the classroom, the bureaucratic norms of the school, colleagues and pupils. Past research has shown that these challenges often influence practice and may be one reason for the too often observed lack of consistency between a teacher's stated beliefs and her practice. In this section, I examined the challenges faced by the participants of this study, the effect these challenges had on their beliefs and their methods for dealing with these challenges.

Classroom Management.

Not unexpectedly, classroom management was mentioned as a challenge to good mathematics instruction. Most of the teachers mentioned a particular incident or child who presented a challenge to managing their classroom effectively, but these problems were generally resolved quickly and posed no on going problems to their instruction. However, Danielle, who taught pre-kindergarten, mentioned particular problems and frustrations:

> It is a lot different teaching pre-k than I anticipated. I have to spend a lot of time teaching mechanics and social skills. This group of children has a difficult time keeping their hands to themselves and so we have spent a lot of time working on that. It is kind of disappointing because I had hoped to spend more time on academics and less on classroom management.

When questioned about how she dealt with such difficulties she responded:

> I have to plan several activities for one class because you never know what kind of day the students will be having. Classroom management is a huge problem with this group. Some of the activities I have planned for the day have to be changed or completely abandoned based on how the kids are behaving that day. These kids are lacking in social skills and so I have to be flexible in what I do with them. Even when a lesson is going well, you still have to change what you are doing constantly. Like today, I was planning on using Fruit Loops to help with counting and patterns but before I knew it we were talking about subtraction. The kids seemed to understand that when someone ate one we had one fewer to count so I thought, "Why not go with it?"

This idea of flexibility in dealing with classroom situations, including student frustrations with understanding concepts, tended to be a frequently used model for the teachers.

Being able to adapt to varying situations and keep students actively engaged seemed to help the teachers maintain student interest and significantly reduce discipline problems. This lack of discipline problems is not typical of first year teachers and can most likely be explained by the teachers' strong belief that students need to be actively engaged in the learning process. By developing lessons that focused on keeping students actively involved in their own learning and by being flexible and adapting those plans as needed, discipline problems were rare and often minor. Four of the five teachers explicitly talked about a need to be flexible and to deviate from the planned lessons when the situation called for it. All seemed to think that it was important to be able to adapt the lessons based on the students' needs, which was in line with their beliefs about how students best learn mathematics.

Assessments.

The first challenge to their teaching that was mentioned by almost all of the teachers was standardized assessments. There were several aspects of these standardized tests that served to challenge their beliefs about the teaching of mathematics. All five used manipulatives on a regular basis and held strong beliefs that all children should be able to use them to investigate and solve mathematics problems. Standardized tests, including those given by the various counties, did not allow for the use of manipulatives, so these teachers expressed concerns that the tests were not in line with current practice. When asked how they dealt with this conflict, the teachers responded similarly to Morgan:

> Morgan: I would love to allow them to use them all the time. However, the current assessments being used do not allow for the use of manipulatives so what I try to do with my students is let them use the manipulatives to figure out the

> concepts and then have them learn to draw the manipulatives. This way when they take the tests they can draw a picture to solve the problem.

All of the teachers found that drawing models was a satisfactory way of dealing with this constraint of standardized testing.

Another complaint with the standardized tests was that they really could not be used to inform instruction. These teachers expressed a belief that informal, daily formative assessments were far more valuable to their practice as teachers than any of the standardized tests. Kayleigh described her concern:

> Kayleigh: We have to do a county mandated CRCT test prep. I don't think this is as helpful to me as informally assessing students. The problems on the CRCT test prep are pretty basic and you can't really tell what the students understand-just that they got the problem wrong. These standardized tests really don't ask good questions. I prefer to give my own tests whenever possible.
>
> Researcher: What makes these tests such poor assessment instruments?
>
> Kayleigh: I think some kids can do a much better job explaining something to me than maybe they can show on a paper and pencil test where there are just right and wrong answers. Other kids can get answers right on a paper and pencil test but not really understand what they are doing. I would rather have kids show me than give a standardized test.

All of the teachers thought that the standardized were limiting their ability to teach mathematics the way that they wanted to and viewed the tests as insufficient in providing important feedback for their teaching.

School Curriculum.

A constraint that was mentioned by all five teachers was the imposed curriculum of their school systems. Four of the five teachers worked at public schools and were operating under the State of Georgia mathematics curriculum. The fifth teacher was at a private Catholic school and was following a curriculum imposed by the Archdiocese of Atlanta. Most of the complaints about the curriculum centered on the order in which topics were to be presented and the amount of time specified for presenting a particular topic. Two teachers pointed out that some mathematical concepts were to be presented before the prerequisite concepts had been taught. For example, Paige stated that her county required that she teach children money concepts before they learned about decimal numbers. Another teacher explained that she was supposed to teach time to 5-minute intervals before students were introduced to the fraction concepts she thought were necessary for complete understanding. Ellen had a particularly challenging task. She was given a workbook that was to dictate the order in which the material was presented. She explained her struggles this way:

> Unfortunately, the teachers at this school allow the workbooks to dictate the curriculum. There is little room for creativity in teaching. We can't do thematic units because the science curriculum is disjoint from the math curriculum, which is disjoint from the social studies curriculum, etc. Each subject is treated separately. I believe that they [the children] would benefit more from big units that integrate everything.

Clearly the organization of the curriculum was a struggle for all of the teachers.

Student Learning.

These young teachers also expressed a concern that not every child can learn at the same pace as is often proposed by the mandated curriculum or the county guidelines. Again, they continued to stand by their belief that all children could learn mathematics but thought that not all children can learn mathematics at the same pace. When asked how they dealt with this challenge all five of the teachers stated that they found creative ways to make additional time for the children who did not understand a concept. Some used time at the end of other subjects, one used centers to continue to address tough topics, and some found ways to integrate the ideas throughout the day, and two revisited topics by integrating them with other ideas that occurred later in the curriculum. For example, after a lesson on even and odd numbers, Kayleigh still had a large number of children who struggled with the concept. She explained her difficulty with the lesson and her solution for dealing with the problem:

> Even though there were a few children who still did not get it, I decided that it would be better to move on and revisit the topic at a later date. All of the second grade teachers have had a problem teaching odd and even so early in the curriculum. For some it took up to three days to cover a topic [odd and even] that was supposed to take up one day, and the kids still did not get it. [Kayleigh only spent one day on the topic initially.] I did, however, take time to reteach the odd/even concept later, once I figured out how to use tiles and make it hands on, and as soon as I did that, light bulbs went off and everyone finally got it.

Other teachers complained that the time lines for teaching concepts did not take into consideration student learning. Morgan stated her concern as follows:

> Morgan: Our school system has strict pacing guides that we must adhere to. You feel very pressured by the county to stick with the pace. So far it has not been a problem. My students have done well with the concepts covered so far but if we run into something that is difficult for them it will be difficult to keep with the pacing guide.
>
> Researcher: What will you do in that situation?
>
> Morgan: I will have to keep up. I will have to find ways to get the concept learned in the time allotted. I can continue to address skills in the math centers. So if I have children who don't master a concept, my centers can continue to address these as well as covering new material.
>
> Researcher: So you can extend the time needed to learn a concept?
>
> Morgan: Exactly. But I can also keep up with the pace set by the county.

When questioned about how they were dealing with the time and curricular constraints, all of the teachers explained that they thought it was important to follow the imposed curriculum and time lines. Each one, however, described how she manipulated her current situation so that she could teach in a way that she believed was best for her students while still meeting the time requirements imposed on her. The decision by these young teachers to be flexible was once again apparent when they were faced with time and curricular constraints. Ellen explained her approach to dealing with these constraints:

> The other thing that I have learned is that you must be ready to move on. If the lesson is a complete disaster then you have to give up and try again the next day. I have a 30 minute rule: If after 30 minutes the lesson is failing, then it is time to move on and revisit the topic on another day. Several of the teachers I work with are committed to the schedule [one hour for math] and will keep at a topic for the entire hour even if they are accomplishing nothing. I think it is better to use less time on one day and then make it up the next time.

This flexibility in adapting and changing lessons, adjusting teaching strategies, and varying approaches was mentioned frequently by all of the participants. This belief about being flexible and adapting to various classroom situations appeared to help these new teachers successfully face the challenges of the classroom without compromising their beliefs about how best to teach mathematics.

Peer Teachers.

One of the most difficult challenges faced by this group of new teachers was dealing with their peer teachers. Each of these teachers was involved in a college program that emphasized collaboration. Because of this they entered their first teaching jobs with strong expectations for some level of collaboration with their peer teachers. This expectation was met with a great deal of disappointment. Instead of finding teams of teachers working together to produce good lessons, they were often met with isolation and resentment.

The teachers from this study identified 4 types of peers that they encountered: the concerned peer, the jealous peer, the negative peer, and the uninterested peer. The concerned peer was mentioned several times as the “nice teacher who is just trying to help." She was described as the teacher who, out of concern for their well being, was constantly trying to influence these new teachers into abandoning their new methods. Concern for their health, social lives and overall well-being were expressed prior to suggestions of taking an easier approach to teaching. Most of the preservice teachers dealt with these peers by politely ignoring their advice and continuing to teach as they believed best. Paige, however, had a more difficult challenge to face with concerned peers. Instead of collaboratively planning lessons, the 4 second-grade teachers at her school had decided that each one would choose a subject and plan the lessons for that subject. These lessons would then be given to the other teachers to use in their classes. While Paige appreciated the lessons, they tended to be traditional in nature, which was not the way she wanted to teach mathematics. Because it was important for Paige to appear to be cooperative with her new colleagues, she decided to accept the lessons and modify them as best she could to fit her beliefs about the teaching of mathematics. She reported that she had been reasonably successful adapting the lessons but at times she just taught them as written. She mentioned that she was usually disappointed in the lessons that she did not modify because she knew there were "better ways to teach the concept." Even though, on observation, it might appear that Paige had abandoned her progressive beliefs about the teaching of mathematics, she clearly indicated that this was not the case but that her beliefs about appearing cooperative were more important to her success as a teacher at this point in time.

One of the toughest challenges faced by 4 of the 5 teachers was that of what one teacher deemed "peer jealousy." Peer jealousy was described as resentment by their peers toward their teaching methods and the success of those methods as shown in student achievement. Morgan described it this way:

> I do things differently from the other teachers so I get criticized frequently. They are always asking me "Why do you spend so much time on that?" or making comments like "You won't do all that after you teach a while." They seem to be jealous of the amount of time I put into my teaching and both the interest my students have in math and their achievement levels. Because of the way I teach my students do better on the assessments, which makes the other teachers unhappy. I think they are afraid that they will be expected to do the same and they are not ready for that amount of work.

Intensifying the peer jealousy was the acceptance of the new methods by the administration. Three of the five teachers mentioned that the administration at their schools had noticed what they were doing within their mathematics classrooms and were very supportive of their methods. While the teachers were thankful and pleased with the administrative support, they did think that it caused the jealousy from other teachers to increase.

The negative peer was experienced by all of the first year teachers and often went hand in hand with the jealous peer. The negative peer was described as a person who resented change and new ideas. All of the teachers described enthusiastically sharing ideas with their peers at the beginning of the year but after frequent encounters with peers who told them that their ideas did not have merit or that they were wasting their time, most of the teachers just shut down and no longer shared with others. Danielle described her experience:

> I've learned to keep my mouth shut so that people at the schools don't resent your ideas. If you express your ideas about teaching math and they're different from what others think you get a lot of resentment.

Kayleigh, however, took a different approach. She refused to shut down and decided that she "did not care what the other teachers thought of me." She was going to share her ideas "whether they liked it or not." She explained that each time she prepared a math lesson she would send it out via email to all of the 2nd grade teachers with an invitation to use it if they liked. After the initial negative phase at the beginning of the year experienced by all of the new teachers, Kayleigh's peers began to accept her ideas and use her lessons. In fact, by the end of October her peers had asked her to become the second grade lead teacher for mathematics because they thought she knew more about the new standards being taught than they did and because her lessons had been so successful with their students.

The uninterested peer was described by Morgan as the teacher who "just does not want to be part of anything." Once again, the teachers described attempting to share ideas and lesson plans with this peer but were met with indifference. This peer had no interest in listening to, considering, or implementing any new ideas and generally had a negative attitude toward those who did. To deal with this peer four of the five teachers simply ignored them. Kayleigh, as mentioned earlier, was persistent and continued to share ideas regardless of her fellow teachers' attitudes or comments.

Additional Constraints.

Other constraints mentioned by this group of teachers included student backgrounds, unsupportive home environments, and language. One of the teachers had a particularly difficult time in developing lessons for two of her students who did not speak English. She also had two students who were almost completely non-verbal. She struggled with knowing how to assess them because they were unable to explain their ideas and what they were thinking. She complained that it was difficult to develop lessons based on these students needs when she could not accurately assess what they knew and did not know. While these were concerns that were mentioned by different teachers, they did not seem to be as widespread or as challenging as the others mentioned. They also did not appear to have any significant impact on the beliefs held by these teachers.

One reality that surprisingly did not seem to have an impact on the teachers' beliefs or actions was the school settings. As described earlier, three of the teachers were placed in schools that were well maintained and provided them with the supplies necessary for teaching as they believed they should. The other two teachers, however, were placed at schools where supplies were scarce and manipulatives were unavailable. Faced with this type of challenge, it would be easy to assume that the two teachers in the schools where supplies were scarce would have a more difficult time maintaining their progressive beliefs about how best to teach mathematics and perhaps abandon their progressive teaching for something more traditional. This, however was not the case. All five of the teachers held true to their beliefs regardless of the setting. Those teachers without supplies found ways of creating or buying their own.

Stability of Beliefs

The most interesting finding of this study was the resolve with which these five young teachers approached their daily challenges. It has been suggested by some researchers (e.g., Cooney 1998) that social teaching norms and the immediate school environment can have a great influence on the development of beliefs especially in beginning teachers who are particularly susceptible to outside influences. However, instead of the fragile belief systems suggested by many previous research studies, these teachers appeared to have firm belief systems in place particularly with regard to their beliefs about the teaching of mathematics. These beliefs appeared to be stable and indicated little change within the first semester of teaching. When faced with a challenge or constraint within the classroom, more often than not, these teachers found ways to either manipulate the constraint so that it would fit into their current beliefs about mathematics and the teaching of mathematics or, at times, they completely defied the imposed constraint by choosing to hold true to their beliefs. Only on occasion did they consciously act in opposition to their beliefs about mathematics, but using Leatham's (2006) framework I determined that in these cases the teachers were not really behaving inconsistently. By looking more deeply at these perceived inconsistencies, I determined that the teachers were able to justify their actions by stating other non-mathematical beliefs about teaching that they thought were more important at that given time.

CHAPTER 5

Summary

Some of the most recent reform efforts in mathematics education have strongly encouraged researchers to look into not only the beliefs of teachers but also the connection between teacher's beliefs and their instructional practice. In response to this plea, there have been many attempts by researchers to find new and better ways to investigate these relationships. Topics such as teacher beliefs, the relationship between beliefs and practice, the interaction between teacher beliefs and student achievement, the changing of teacher beliefs, the relationship between beliefs and teacher learning, and the relationship between teacher beliefs and student learning are all covered under the broad umbrella that is beliefs, making it a challenging field to study. While I have found all of these areas to be fascinating, my research focused on the somewhat neglected area pertaining to how the mathematical beliefs of teachers are affected by the challenges and constraints of the classroom.

I set out to examine the beliefs held by elementary teachers regarding the nature of mathematics and mathematics teaching as they entered the classroom and became first year teachers. The study was designed to determine whether or not changes in their beliefs occurred during this first semester of teaching. While pursuing my research, I looked at three major questions: (a) What beliefs about the nature of mathematics and the teaching of mathematics did first year teachers have prior to entering the classroom? (b) Did the beliefs of these beginning, elementary school teachers change when faced with the challenges and realities of the classroom? and (c) What were the greatest challenges to their beliefs about mathematics and did these factors help promote a change in their beliefs?

There were three main reasons for my desire to explore this area of research. They were a) research focusing on first year teacher's formation of beliefs as they struggle to develop their teaching practice is rare; b) beginning teachers' beliefs are likely to be challenged in their first year of teaching as their recently developed beliefs about mathematics and pedagogy are pitted against the realities of the classroom; and c) beliefs research often focuses only on the influences that mathematical beliefs have on decision making and does not consider the influences of beliefs held outside this context. I felt that, as a mathematics educator, developing a better understanding of how steadfast young teachers beliefs are when introduced to the pressures of being a first year teacher was important both to these teachers and to the preparation of future teachers.

As a result of investigating how teacher beliefs are affected during the first year of teaching, I also hoped to determine what external influences had the greatest impact on these beliefs. It is important for all who are involved with the preparation of future teachers, as well as those who are responsible for the support of current teachers, to understand what external factors influence the beliefs of teachers and to what extent these influences change those beliefs. By increasing our understanding of the impact these external influences have on new teachers, teacher educators and school administrators will be better able to help minimize the influences that cause unwanted changes, enhance those that cause positive changes, and support those that sustain beliefs consistent with our current understanding of best practices.

Keith Leatham's (2006) sensible system framework was used to guide this research. In his framework, Leatham (2006) suggested that teachers be treated as sensible, rational individuals and to assume that it is impossibility for a teacher's actions to be irrational and counter to the beliefs she holds. Adopting this new perspective allowed me to look more deeply at both the implicit and explicit, mathematical and non-mathematical beliefs that were held by practicing teachers. I was also able to avoid some of the common pitfalls associated with beliefs research. Instead of focusing on the inconsistencies in stated beliefs or between teachers' actions and stated beliefs, I was able to look more deeply at the beliefs themselves. I was better able to determine what beliefs might be causing the perceived inconsistency and whether these beliefs were directly related to mathematics and the teaching of mathematics or whether they were more general beliefs about teaching and learning. In addition, the sensible system framework provided me with methodological implications for inferring the beliefs of each individual teacher (Leatham, 2006). I was encouraged to explore teachers' beliefs more deeply by using a variety of methods, which helped to minimize any inconsistencies in interpretations of the beliefs.

To begin my study of beliefs, I first had to undertake the difficult task of defining what I meant by beliefs. Researchers such as Pajares (1992) have spent a great deal of time and energy in an attempt to establish a widely accepted definition of the term belief but as of today no common, universally accepted definition currently exists (Goldin, 2009). Through Leatham's (2006) framework I was able to develop a working definition of the term beliefs. I adopted his definition of beliefs in which both knowledge and specific beliefs about mathematics and the teaching of mathematics are seen as sub-sets of a much larger set of beliefs and not as two separate ideas.

To begin my research, all elementary preservice teachers (*n* = 63) at a small liberal arts college in their last semester of an early childhood program were given a beliefs survey that consisted of groups of statements about both the teaching of mathematics and the nature of mathematics. The survey was constructed with Likert scale responses and was used to indentify those students with more progressive beliefs about mathematics and the teaching of mathematics. After scoring the initial survey, 5 participants who scored in the top 25% of the group were chosen for the study. Questions and responses from the initial survey were then used to design a protocol for future interviews.

Initial interviews were conducted prior to the beginning of the participants' first year of teaching. This interview was designed to clarify responses on the survey and to help ensure that the beliefs students held prior to entering their first year of teaching were accurately reflected. Further interview data was collected during the teachers first semester of teaching. As encouraged by Leatham's (2006) framework, data were collected through a variety of methods including observations, interviews, focus groups and a final beliefs survey. Questions for the interviews and focus groups were a combination of predetermined questions that all participants were asked and questions that emerged from the observations.

In evaluating the results of the survey and the interviews it was necessary for my analysis to separate the qualitative data into two beliefs categories: Nature of Mathematics and Teaching of Mathematics. To further analyze their beliefs, I separated each of these main categories into subcategories. The nature of mathematics category was separated into areas looking at mathematics as created or discovered, the rigidity of mathematics, attainability, the purpose of mathematics, and the integrated nature of mathematics. The teaching of mathematics category was separated into autonomy, student/teacher centered instruction, mathematical approaches, student learning, importance of reflection, and reform methods. During the interview process, each statement given by the teachers was evaluated and coded based on the expressed belief in relation to the listed categories, the traditional or progressive orientation of the belief, and the challenges or constraints influencing the belief.

Statements about the teaching of mathematics were abundant but comments on beliefs about the nature of mathematics were rare. These young teachers admitted that, while they spent a great deal of time reflecting on their teaching practice, they rarely reflected on ideas regarding the nature of mathematics. Their views and practices relating to the teaching of mathematics were overwhelmingly progressive despite the identified challenges that they faced. While most of their views about the nature of mathematics were also progressive, including their views on mathematics as being interrelated, students' abilities to understand mathematics, and conceptual learning, there were some areas that appeared to be less so. For example, most of the teachers entered the study with a view of mathematics as a rather static body of knowledge with the first semester of teaching only serving to strengthen this belief.

Conclusions

This study was a first step in determining how steadfast the beliefs of young teachers are when faced with the challenges and constraints of the classroom. The most interesting finding of this study was the resolve with which these five young teachers approached their daily challenges. It has been suggested by some researchers (e.g., Cooney, 1998, Szydlik, 2003) that social teaching norms and the immediate school environment can have a great influence on the development of beliefs especially in beginning teachers who are particularly susceptible to outside influences. However, instead of the fragile belief systems suggested by many previous research studies, these teachers appeared to have firm belief systems in place particularly with regard to their beliefs about the teaching of mathematics. Whether their beliefs were progressive or, on occasion, more traditional, the first semester of teaching appeared to have had little impact on them. Only a couple of beliefs seem to have shifted slightly and these changes could not be considered significant. Overall, the teachers' beliefs were progressive, stable, and indicated little change within the first semester of teaching.

The stability of their beliefs was demonstrated throughout the first semester. When faced with a challenge or constraint within the classroom, more often than not, these teachers found ways to either manipulate the constraint so that it would fit into their current beliefs about mathematics and the teaching of mathematics or, at times, they completely defied the imposed constraint by choosing to hold true to their beliefs. Only on occasion did they consciously act in opposition to their beliefs about mathematics but, using Leatham's (2006) framework, I determined that in these cases the teachers were not really behaving inconsistently. By looking more deeply at these perceived inconsistencies, I found that the teachers were able to justify their actions by stating other non-mathematical beliefs about teaching that they thought were more important at that given time. This finding is consistent with other research (eg. Benbow, 1995, Thompson,

1984) that demonstrated that many factors influence the instructional decisions and behaviors of teachers including beliefs about teaching that are not specific to mathematics.

An unexpected finding of the research process was the link between student success and the strength of the teachers' beliefs especially about the teaching of mathematics. Their perception of their success in encouraging student learning appears to have been a contributing factor in maintaining their progressive beliefs. Beliefs that supported the successful development of student learning, such as the importance of using manipulatives or the need to develop conceptual understanding before procedural skills, were affirmed and strengthened despite the challenges they faced. Other beliefs, which were not as clearly supported by student learning such as individual student abilities, were more readily questioned. Even though the teachers still held to their progressive beliefs, they felt a need to qualify or clarify those beliefs that were not as well supported by student success. It was clear from both the observations conducted and the discussions held that student success was crucial in maintaining progressive beliefs about the teaching of mathematics.

Several challenges to the young teachers' beliefs were identified during this study. Those included curriculum time lines, student abilities, assessments, and discipline and each had an impact on these new teachers. Surprisingly, however, the most difficult challenge to their progressive views about mathematics and the teaching of mathematics turned out to be their peer teachers. Each of the new teachers had been involved in a college program that emphasized collaboration. Because of this, they entered their first teaching jobs with strong expectations for some level of collaboration with their peer teachers. Unfortunately, this expectation was met with a great deal of disappointment. Instead of finding teams of teachers working together to produce good lessons, they were often met with isolation and resentment. Initially, they were unprepared for this particular challenge. All of the teachers described enthusiastically sharing ideas with their peers at the beginning of the year but after frequent encounters with peers who told them that their ideas did not have merit or that they were wasting their time, most of the teachers just shut down and no longer shared with others.

The teachers from this study identified 4 different types of peers at their schools that had an impact on them: the concerned peer, the jealous peer, the negative peer, and the uninterested peer. The concerned peer was described as the teacher who, out of concern for the young teacher's well being, was constantly trying to influence them into abandoning their new methods. The jealous peer was the most troublesome and was described as the peer who resents the success of new teaching methods as shown in student achievement and the positive attention that it brings from administrative figures. The negative peer was described as a person who just resents any change or new idea. The uninterested peer was described as the teacher who just does not want to, or have the time to, be bothered by new ways of operating in the classroom. Each of these peers provided a significant challenge to the new teachers' beliefs about the best way to operate within their own classrooms.

Impact on University Programs

Many have argued that the study of beliefs is a necessary and valuable avenue of educational inquiry (Pajares, 1992). The importance of understanding beliefs about mathematics and the teaching of mathematics and how those beliefs are challenged by the experiences of teaching was solidified by this study. Leatham (2006) pointed out that understanding how beliefs are held and how they relate to one another has the potential to greatly influence the practice of teacher education. By better understanding teachers' beliefs and the challenges to those beliefs, teacher educators can help provide experiences and support to future teachers that will positively affect their beliefs about mathematics so that newer, more progressive beliefs will move high on the list of beliefs that most affect the practice of teaching (Leatham, 2006). Perhaps the greatest impact from studying beliefs will be the improvement of teacher education.

Previous research on the impact that colleges and universities have on the formation of beliefs of preservice teachers has generally concluded that higher education has moved preservice teachers in the direction of decreased authoritarianism and dogmatism toward increasingly liberal beliefs (Zeichner, 1981). The formation and maintenance of these progressive beliefs is of great importance to producing future educators. Mc Diarmond (1991) suggested that instead of focusing on the issues with which teacher educators agree with their students, teacher educators must challenge students' initial beliefs if they are to see any real shift toward more progressive beliefs. Without being challenged many elementary teachers complete their college program without any real opportunity to examine their fundamental beliefs about the teacher's role in the classroom (McDiarmond, 1991).

Perhaps one of the primary goals of teacher education should be to stimulate the examination and development of beliefs about mathematics and the teaching of mathematics (Raymond, 1997). Before entering a classroom it is important that first year teachers understand what it is that they believe. They should be able to explicitly state and explain their philosophy of teaching and learning before they are faced with the challenges of a real classroom. By helping them explore these ideas before becoming practicing teachers, mathematics educators might have a stronger impact on teaching practice. This research showed that students who leave their college programs with strongly held progressive beliefs are able to maintain those beliefs despite the challenges they faced.

Another important finding of this study with implications for teacher education was the fact that it emphasized the need to improve ongoing dialog and support for these young teachers. As Artz (2003) explained, teacher candidates need to have a support system that encourages the taking of risks and creates a venue for interpretation when the attempts fail. In this study I found that the elementary teachers involved had been able to develop a strong support system while in college. This system included, a mentor leader, content specialists, carefully selected practicum teachers, and a cohort of peers. However, after leaving college, this support system was in stark contrast to the isolation they found within their own classrooms. The only ongoing support they found as new teachers came from their former college peers who they continued to remain in contact with and not from their new peer teachers. A couple of teachers also found support from school administrators who were happy to see a rise in students' test scores. This support, however, was not always welcomed as it often created jealousy and resentment among their peer teachers. The new teachers in this study expressed a real desire to collaborate and discuss issues and actively sought out support from other teachers, but instead of finding support, most were met with resentment of their "new" ideas.

To combat this lack of support, teacher education programs must prepare students to face a barrage of challenges. By focusing on the experiences that occur in the first year of teaching, mathematics educators can identify and make use of the affordances and constraints of the classroom and their association to the beliefs held about mathematics and the teaching of mathematics. To withstand the challenges and maintain their progressive beliefs, it is important that teachers leave their college programs with a clear set of beliefs, especially with regard to the teaching of mathematics. By challenging the existing beliefs of preservice elementary teachers in a way that encourages the development and strengthening of beliefs that are more progressive, it is clear from this study that these new beliefs can become the driving force behind what these teachers perceive as the best way to teach mathematics. This study has shown that teachers with strong, progressive beliefs are able to withstand first year challenges and retain their beliefs. Additionally, it has shown that the behavior of young teachers is not typical of many first year teachers. Their strong commitment to their progressive beliefs positively affected the way in which they conducted their classrooms. This resolve to conduct their classrooms differently from many of their peers was reinforced by an increase in student learning, which, in turn, appeared to encourage their continued resolve to teach as they believed best. Clearly, helping prospective teachers develop more progressive beliefs prior to entering the classroom is not a waste of time. Based on these results, it is imperative that teacher education programs help students develop these strong beliefs and ways to sustain them prior to entering the classroom.

Limitations and Future Research

In order to gain a better understanding of the impact that the real world classroom has on the beliefs of first year teachers, much work needs to be done. While this study helped add to our understanding of the beliefs held by new teachers and the effects of the classroom, it clearly had some limitations. This study produced some interesting results that contradicted much of the research regarding changes in beliefs and the challenges of the classroom; however, with only 5 participants, it would be difficult to extrapolate its findings to a much larger population. In addition, the chosen teachers for this study all began the study with strongly held, progressive beliefs that reflected those practices called for in the NCTM (2000) standards. The findings of this study might be quite different with another group of young teachers with less progressive beliefs. It would be interesting to repeat this study with a larger group of students initially exhibiting a wider range of beliefs.

Additionally, this study focused on the changes to teachers beliefs about mathematics and the teaching of mathematics; however, it did not address their formation or the depth at which the beliefs were held. Many researchers (e.g. Cooney, 1998) argue that it is much easier to change newly acquired beliefs than those that have been held for longer periods of time. In attempting to determine the length and depth at which certain beliefs were held, it would have been interesting to see if the participants of this study entered their teacher education program with their progressive beliefs or if their program of study helped form and shape them. Because of the results of the piloted survey with the juniors, I would suspect that the participants' beliefs, especially about the teaching of mathematics, had been formed and strengthened during their two years in the cohort program. However, there is no data to support this claim, and even though it is unlikely, there is a possibility that the reason almost no changes in beliefs occurred with this group of teachers is because their beliefs were deeply held and had been a part of their belief systems for a relatively long period of time. In future studies, it would be beneficial to identify the teachers' beliefs about mathematics and the teaching of mathematics prior to entering their college program.

While the findings of my study showed teachers with firmly set beliefs that were maintained during the first semester of teaching, I have to wonder if these beliefs will be as firmly set in the next few years. With the constant challenges faced in teaching elementary school and the grueling schedules they have imposed on themselves, I have to wonder if this group of young teachers can continue to hold true to their beliefs about the best ways to teach mathematics or whether other beliefs, such as beliefs about appearing cooperative and conforming to the expected norms of their schools, will begin to erode their beliefs about mathematics and how to teach mathematics. Additionally, I have to question if I would get the same results if these teachers had been placed in higher grade levels where students are less open to new ideas and have already developed an expectation of what mathematics is and how a mathematics class looks. High stakes testing is also introduced in the higher-grade levels and I have to wonder if this would have an impact on classroom instruction. For this reason, it is important for the field to conduct more longitudinal studies that begin as this study did but then continue to follow the teachers throughout their first few years of teaching. It would be very interesting to see what effects time and continuous challenges have on their beliefs.

There must be one final qualification to this work. Because this study involved teachers who were formerly my students, there is a possibility that their responses to the surveys and during the interviews were influenced by my presence. In other words, it is possible that the teachers responded in a way that they thought would be pleasing to me and that did not accurately reflect their true beliefs. To help ensure that I did not let my connection to these teachers sway the research process in any way, I was careful to make the teachers comfortable in expressing their views and to not judge those students who held beliefs different from those presented by me throughout their mathematics education courses. To help minimize my subjectivities, as suggested by Leatham's (2006) sensible system framework, I followed up each survey and observation with an interview. This interview helped me clarify the participant's responses and ensure that my interpretation of their responses was as accurate as possible. In future studies, I would like to involve other researchers to help minimize my personal influence on the participants and make the entire process less subjective.

Final Thoughts

As Keith Letham (2006) pointed out, "Research on teacher beliefs, although fraught with pitfalls to avoid and difficulties to surmount, has great potential to inform educational research and practice and is therefore worth the effort" (p. 91). There is substantial evidence to show that the beliefs teachers' hold directly affect the way in which they view or even understand mathematics and therefore, the way in which they teach mathematics. Because of the impact beliefs have on the teaching of mathematics, it is imperative that teacher educators understand how to nurture beliefs that are consistent with current understandings of best practices. Many previous research studies have been designed to explore the development of these beliefs within college courses or carefully designed summer workshops. While these studies are important to the field of mathematics education, our job is not finished. We must continue to investigate the stability of beliefs once the teachers leave these programs and enter their own classroom. The question still remains, "What happens to progressive beliefs about mathematics and the teaching of mathematics once teachers enter the classroom?" I attempted to help answer this question. Giving support to our work as mathematics educators, I found that the 5 elementary teachers left their college program with strong, progressive beliefs about mathematics and the teaching of mathematics and were able to maintain those beliefs despite the challenges and constraints they faced in their own classrooms. This result was encouraging but somewhat surprising based on previous studies describing the fragile beliefs of young teachers. An important implication of this study is that, by identifying the most significant challenges to the beliefs of these new teachers, mathematics educators and school administrators will be better able to determine the amount and type of support necessary to nurture and maintain the progressive beliefs of young teachers once they leave college. This type of support for new teachers currently appears to be missing.

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Appendix A

Mathematical Beliefs Survey

Consider the following statements. Circle the response that best describes your agreement with each of the statements. Feel free to make comments on any of the statements.

1. One of the best things about mathematics is that its content is unchanging. **Disagree Somewhat Disagree Somewhat Agree Agree**

2. Mathematics teachers should spend most of their class time facilitating students' mathematical understanding and not worrying about covering everything in the textbook. **Disagree Somewhat Disagree Somewhat Agree Agree**

3. The use of manipulatives in mathematics is an aid primarily for slow learners. **Disagree Somewhat Disagree Somewhat Agree Agree**

4. As a teacher, it is important to check all of your solutions with the textbook to be sure they are accurate. **Disagree Somewhat Disagree Somewhat Agree Agree**

5. Mathematics is more of a subject of ideas and mental processes than it is a subject of facts. **Disagree Somewhat Disagree Somewhat Agree Agree**

6. Good mathematics teachers show students the exact steps needed to answer questions. **Disagree Somewhat Disagree Somewhat Agree Agree**

7. The key to being successful in mathematics is remembering what to do for each type of problem. **Disagree Somewhat Disagree Somewhat Agree Agree**

8. Working hard will increase your ability to understand mathematics. **Disagree Somewhat Disagree Somewhat Agree Agree**

9. To avoid confusion, teachers should encourage students to solve problems only by the methods presented in class or those found in their textbook. **Disagree Somewhat Disagree Somewhat Agree Agree**

10. Students should be given opportunities to investigate open-ended mathematical investigations even if there is no clear solution. **Disagree Somewhat Disagree Somewhat Agree Agree**

11. It is important for teachers to consider what children know and understand when making decisions about mathematics instruction. **Disagree Somewhat Disagree Somewhat Agree Agree**

12. Discovery and justification are essential processes in mathematics at all levels. **Disagree Somewhat Disagree Somewhat Agree Agree**

13. To be successful in mathematics, students must practice procedures frequently until they become comfortable with the process. **Disagree Somewhat Disagree Somewhat Agree Agree**

14. Truly understanding mathematics requires special abilities that only some people possess. **Disagree Somewhat Disagree Somewhat Agree Agree**

15. Small group or partner activities should be a regular part of the mathematics classroom. **Disagree Somewhat Disagree Somewhat Agree Agree**

16. Students should be given numerous opportunities to reflect on what they have learned in the mathematics classroom. **Disagree Somewhat Disagree Somewhat Agree Agree**

17. It is not as important to understand why mathematics behaves as it does but instead to know how to solve a given problem. **Disagree Somewhat Disagree Somewhat Agree Agree**

18. The main objective of the study of mathematics is to develop reasoning skills that are necessary for solving problems. **Disagree Somewhat Disagree Somewhat Agree Agree**

19. Mathematics is "black and white," there are no ambiguities in the subject. **Disagree Somewhat Disagree Somewhat Agree Agree**

20. Mathematics is created by humans and is used to describe various phenomena. **Disagree Somewhat Disagree Somewhat Agree Agree**

21. Students must be actively involved in mathematics class in order to understand the mathematics they are learning. **Disagree Somewhat Disagree Somewhat Agree Agree**

22. Time spent on inquiry and reflection in the mathematics classroom detracts from the more important task of presenting the content. **Disagree Somewhat Disagree Somewhat Agree Agree**

23. Students learn best by attentively watching the teacher carefully demonstrate procedures and methods for performing mathematical tasks and by practicing those procedures. **Disagree Somewhat Disagree Somewhat Agree Agree**

24. In mathematics, if a student understands the basic concepts behind a problem, they can usually figure it out. **Disagree Somewhat Disagree Somewhat Agree Agree**

25. Mathematics can be described as a web of interrelated topics, it is impossible to separate one topic from another. **Disagree Somewhat Disagree Somewhat Agree Agree**

26. Most students, with minimal guidance from the teacher, can develop an understanding of important mathematical ideas. **Disagree Somewhat Disagree Somewhat Agree Agree**

27. Knowing the appropriate facts, algorithms and procedures will guarantee success in all mathematics classes. **Disagree Somewhat Disagree Somewhat Agree Agree**

28. Assigning numerous practice problems to students is necessary to ensure that learning is taking place. **Disagree Somewhat Disagree Somewhat Agree Agree**

29. Mathematical content is fixed and predetermined, as it is dictated by the ideas already present in the physical world. **Disagree Somewhat Disagree Somewhat Agree Agree**

30. Mathematics can be described as a set of rules and formulas. **Disagree Somewhat Disagree Somewhat Agree Agree**

31. Mathematical ability is something a person is born with and it can not change significantly throughout their lifetime. **Disagree Somewhat Disagree Somewhat Agree Agree**

32. Students can best understand mathematics by discovering its ideas on their own or in peer groups. **Disagree Somewhat Disagree Somewhat Agree Agree**

33. It is important that students understand the logic behind the procedures that they are using to solve problems. **Disagree Somewhat Disagree Somewhat Agree Agree**

34. Mathematical ideas exist independently of human ability to discover them. **Disagree Somewhat Disagree Somewhat Agree Agree**

35. With effort “regular” people can become competent in mathematics. **Disagree Somewhat Disagree Somewhat Agree Agree**

36. It is the teacher’s responsibility to eliminate any possible student frustrations by carefully showing her students the steps for solving problems. **Disagree Somewhat Disagree Somewhat Agree Agree**

37. People who struggle with mathematics generally have difficulty memorizing facts and formulas. **Disagree Somewhat Disagree Somewhat Agree Agree**

38. Skill in computation should always precede problem solving (word problems). **Disagree Somewhat Disagree Somewhat Agree Agree**

39. The role of the mathematics teacher is to present the mathematics content by stressing the underlying rules and procedures that are to be followed. **Disagree Somewhat Disagree Somewhat Agree Agree**

40. When students pose interesting questions about mathematics, the teacher should be flexible enough to leave her planned lesson and explore the student's ideas. **Disagree Somewhat Disagree Somewhat Agree Agree**

41. Mathematics consists of several discrete and unrelated strands such as computation, geometry, and algebra. **Disagree Somewhat Disagree Somewhat Agree Agree**

42. Mathematics is created only by very prodigious and creative people; other people just try to learn what is handed down. **Disagree Somewhat Disagree Somewhat Agree Agree**

43. Teachers should encourage students to improvise mathematical approaches in solving problems. **Disagree Somewhat Disagree Somewhat Agree Agree**

44. Mathematics instruction is the means for directly transferring information from the teacher to the student. **Disagree Somewhat Disagree Somewhat Agree Agree**

45. It is the responsibility of the teacher to direct and control all instructional activities, including classroom discourse. **Disagree Somewhat Disagree Somewhat Agree Agree**

46. Mathematics is continually expanding its content and undergoing changes to accommodate new developments. **Disagree Somewhat Disagree Somewhat Agree Agree**

47. Students' learning of mathematics depends solely on the teacher. **Disagree Somewhat Disagree Somewhat Agree Agree**

48. To ensure that students are learning, it is important that they be able to work independently of other students. **Disagree Somewhat Disagree Somewhat Agree Agree**

49. Once something has been proven mathematically, it is absolute and can not be changed. **Disagree Somewhat Disagree Somewhat Agree Agree**

50. Since mathematics is created by people, it can be changed at any time to reflect new ideas. **Disagree Somewhat Disagree Somewhat Agree Agree**