Factors Affecting Elementary Mathematics

Teachers' Beliefs Over Time

by

AMANDA GANTT SAWYER

(Under the Direction of Denise A. Spangler)

ABSTRACT

Some researchers found that preservice mathematics teacher education programs have little effect on elementary mathematics teacher beliefs (Hiebert, Gallimore, & Stigler, 2002; Raymond, 1997). Spangler, Sawyer, Kang, Kim, and Kim (2012) identified that a preservice teacher education program can influence beliefs for some mathematics teachers. However, for each of these studies, the question still remains as to what happens to these beliefs and teaching practices after the first two years of teaching.

In this study, I explored three elementary mathematics teachers from Spangler et al.'s (2012) investigation 10 years after their preservice education program ended to investigate their current beliefs about the nature of mathematics, teaching mathematics, and learning mathematics and how these beliefs compared to those they held during their second year of teaching. I used the Integrating Mathematics and Pedagogy (IMAP) Belief Survey, interviews, classroom observations, Known Factors Affecting Belief Change Survey, and a focus group interview to compare their beliefs from their junior year of college to their 10th year teaching to determine the factors that influenced their beliefs.

I constructed a mapping of the factors the participants identified to the beliefs or teaching practices they influenced. From this mapping, I found that the category of factor did not determine the beliefs or teaching practices it affected. From the mapping and defining of beliefs, some conclusions were made about what affects elementary teachers over time. First, the data showed that their teacher education programs might not initially influence individuals, but later, the individuals could become aware of their beliefs and take practices taught in teacher education programs into consideration. Second, I found that teacher education programs had a lasting impact on these participants. Third, after the participants graduated, their new roles as wives and mothers affected how they view their beliefs and teaching practices. Finally, the participants identified economic situations as powerful factors affecting how they teach their students. Much was learned from these three teachers' experiences over time, and this knowledge can help influence future elementary teachers.

INDEX WORDS: Teacher Beliefs, Teacher Education-Inservice, Elementary, Teachers' Belief Change

FACTORS AFFECTING ELEMENTARY MATHEMATICS

TEACHERS' BELIEFS OVER TIME

by

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CHAPTER 1

INTRODUCTION

In a Carnegie (2006) report, Vartan Gregorian stated, “Well-educated, knowledgeable teachers are essential to ensuring the progress of our nation and our society. After all, it is to our teachers that we entrust our most valuable asset – our children, and hence, our future” (p. 1). Developing these educated, knowledgeable mathematics teachers is far more difficult than was once thought (Ball, 1990; Ma, 1999; Sowder, Philipp, Armstrong, & Schappelle, 1998).

Teachers enter the workforce with previously constructed ideas about mathematics teaching and learning. Formed from their years of being students in the educational system, teachers hold strong images of teaching that influence how they approach their teacher education programs (Britzman, 1991). Once in the teacher education program, preservice teachers typically value practicing teachers’ views over the practices supported by their teacher education programs (Scott, 2005). After they become practicing teachers, internal motivation or extended external support are the main causes for teachers to change their teaching practices (Chapman, 2002). As a mathematics teacher educator, I was curious as to what influence all these factors have on teachers.

Many individuals experience mathematics as a student in a traditional teaching environment where teachers lecture and students memorize. Teacher education programs are expected to reform these traditional views of mathematics that were reinforced over 12 years, but researchers have found many teacher education programs did not influence teachers’ teaching practices (Raymond, 1997; Scott, 2005). As Raymond (1997) speculated, “It is possible that teacher education programs do not have the power to directly influence teaching practices beyond a certain level, at least not initially" (p. 572). However, other researchers have documented aspects of teacher education programs that can be influential in changing beliefs about mathematics as well as teaching practices (Hart, 2002; Lubinski & Otto, 2004; Spangler, Sawyer, Kang, Kim, & Kim, 2012; Swars, Hart, Smith, Smith, & Tolar, 2007). However, for each of these studies, the question still remains as to what happens to these beliefs and teaching practices after the first two years of teaching.

After entering the profession, inservice teachers are bombarded with pressures from districts, administrators, mathematics coaches, fellow teachers, and parents to have their students perform well on standardized tests and understand the mathematical standards set for their designated grade level. Many teachers resort to what researchers call a focus on survival (Leatham & Peterson, 2010; Nolan & Hover, 2004). In survival mode, teachers prioritize day-to-day responsibilities and classroom management over crafting mathematical teaching techniques, which results in teachers having lackluster outcomes and lack of direction in the classroom (Leatham & Peterson, 2010).

Chapman (2002) identified three kinds of inservice teachers, "those who change their teaching on their own, those who change their teaching with external support, and those who do not change their teaching in spite of involvement in professional development programs" (p. 178). Given all of these influences on preservice and inservice teachers, I was curious about what affects teachers' beliefs and practices. Thus, I conducted a study of three teachers with 10 or more years of experience to document their current beliefs and practices and to find out what had influenced their teaching practices and beliefs. These teachers participated in a previous study when they were preservice and induction year teachers, so part of my goal was to see if, how, and why their beliefs and practices had changed in the intervening years.

The Importance of Addressing Beliefs

I investigated teachers' beliefs about the nature of mathematics, teaching mathematics, and learning mathematics. I chose to study beliefs because, as Goldin, Rosken, and Torner (2009) stated, "beliefs matter. Their influence ranges from the individual mathematical learner and problem solver and the classroom teacher, to the success or failure of massive curricular reform efforts across entire countries" (p. 14). Beliefs matter because, as Pajares (1992) explained, they are the best predictors we have of decisions individuals make in their lives. Therefore, I collected data on teachers' beliefs and the influences on those beliefs.

Researchers found beliefs influence teaching practice (Green, 1971; Leatham, 2006; Raymond, 1997). These beliefs range from beliefs about the best ways to teach mathematics to beliefs about how to keep their jobs. How individuals enact their beliefs is based, in part, on how the beliefs are structured in the individual. Green (1971) proposed that beliefs have a quasi-logical structure constructed of primary beliefs and derivative beliefs, with primary beliefs being especially difficult to change. Doyle (1990) argued that beliefs about teaching and learning are stable, yet stability does not infer that beliefs are immutable.

Spangler et al. (2012) investigated a group of preservice teachers across their teacher education program into their second year of teaching to document belief change. Three of their participants experienced a belief change across the four years, and one participant's beliefs stayed constant throughout the program into her second year of teaching. Spangler et al. documented specific activities in the teacher education program that helped change their beliefs. Research has shown that "beliefs are reciprocally stabilizing, as they are interwoven into systems with other beliefs" (Goldin et al., 2009, p. 8). Thus, I was curious about whether the beliefs of teachers in my study stabilized or continued to change beyond their second year of teaching. The literature offers little evidence of factors that influence beliefs over time that might interfere with the stabilizing process. Therefore, I studied three of the participants from Spangler et al.'s (2012) investigation to document their beliefs and elicit their perspectives on factors that influenced changes in their beliefs after 10 years of teaching.

The Importance of Addressing Factors

As noted by the National Research Council (1989), "Much of the failure in school mathematics is due to a tradition of teaching that is inappropriate to the way most students learn" (p. 6). Researchers addressed the failure by determining the influences causing teachers to hold on to the tradition of teaching that is inappropriate to their students' learning (e.g. Ambrose, 2004; Battista, 1994; Ernest, 1989). Yet, researchers are not aware of all the factors developing and changing mathematics teachers (Richardson, 1996). Such research would allow us the opportunity to determine events that help produce sustainable, consistent belief change in individuals. I studied three elementary mathematics teachers with 10 years of teaching experience to determine the factors affecting their belief development over time.

Other researchers have investigated factors affecting belief change in teachers (Clandinin, 1986; Doyle, 1990; Leinhardt, 1988). However, they have not studied their longitudinal effects. Raymond (1997) studied the influences on teachers' beliefs and practices for first and second year elementary mathematics teachers. She identified some elements affecting belief change and constructed a model to interpret the strength of the influences. Richardson (1996) identified three influences on teachers' beliefs: personal experience, experience with schooling and instruction, and experience with formal knowledge. The factors were explored in research projects conducted in various fields of education to determine their influence on teachers' beliefs, but these factors were not investigated over a long periods of time (Richardson, 1996). The factors studied in the literature did not specify what belief they influenced, so in my study, I propose a mapping of the specific factors to the belief about the nature of mathematics, teaching mathematics, and learning mathematics they affect.

The Importance of This Study

Although Richardson (1996) identified some factors affecting beliefs in teachers, she stated, "An understanding of the relationship between beliefs and learning to teach, however, would be enhanced by longitudinal studies of teachers who move from preservice teacher education into teaching practice" (p. 110). I conducted this study investigating elementary mathematics teachers 10 years after their preservice education program to investigate their current beliefs about the nature of mathematics, teaching mathematics, and learning mathematics, and how these beliefs compared to those they held during their second year of teaching.

This study is needed to provide a bridge between the preservice teacher education research on belief change and the research focused on belief change conducted on inservice teachers. By studying these participants from their preservice teacher education program through their second year of teaching and after 10 years of teaching, I gained insight into how the teachers formed their initial beliefs and teaching practices and what happened to their beliefs after their teacher education program. The study helps answer the question of whether belief change that occurred in a teacher education program can be sustained. I also looked into the personal influences in teachers' lives after their teacher education program that influenced beliefs.

The Purpose and Research Questions

The purpose of this study was to determine the beliefs of a specific group of elementary mathematics teachers who were in at least their 10th year of teaching to determine what influenced their current beliefs about the nature of mathematics, teaching mathematics, and learning mathematics, as well as to discover other influences affecting their beliefs over time. These teachers graduated from the same teacher education program with the same mathematics methods instructor and had participated in a prior study. Through four interviews, two surveys, and three classroom observations, I examined the following questions:

1. What are these elementary teachers' teaching practices and beliefs about the nature of mathematics, teaching mathematics, and learning mathematics after 10 or more years of teaching?
2. How have these elementary teachers' beliefs about the nature of mathematics, teaching mathematics, and learning mathematics changed since their second year of teaching?
3. What factors contributed to the formation of these beliefs?

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Pajares (1992) argued that “Beliefs are the best indicators of the decisions individuals make throughout their lives” (p. 307). Thus, beliefs are important constructs to study, and many researchers have investigated belief structures, systems of beliefs, and categorizations for identifying beliefs (e.g., Ernest, 1989; Green, 1971; Leder, Pehkonen, & Torner, 2002). In this chapter, I begin by defining beliefs, belief structures, and belief systems. Then, I describe how I categorize beliefs in my study and provide an overview of the literature on belief change and factors influencing beliefs. I conclude this chapter by describing related literature that was found to be significant through my investigation.

Defining Beliefs

Because there are a variety of definitions for “beliefs,” I used the definition offered by Philipp (2007): “psychologically held understandings, premises, or propositions about the world that are thought to be true” (p. 259). I selected this definition because it identifies beliefs’ psychological aspects. Beliefs are individually constructed, yet they are influenced by social and cultural factors. By this definition, beliefs are individual psychological understandings about the social world that individuals find valid.

To clarify my definition, I distinguish beliefs from affect, attitude, conceptions, and knowledge. These terms help to define my understanding of what is a belief by either identifying what beliefs do not include or what larger concept includes beliefs.

I view affect as “a disposition or tendency or an emotion or feeling attached to an idea or object” (Philipp, 2007, p. 259). By this definition, affect includes emotions, attitudes, and beliefs. These three concepts can be distinguished by their stability and ability to change. Emotions are viewed as “feelings or states of consciousness, distinguished from cognition” (Philipp, 2007, p. 259). Emotions are viewed as easily changed and less cognitive than attitudes and beliefs. I define attitudes as “affective responses that involve positive or negative feelings of moderate intensity” (McLeod, 1992, p. 581). Attitudes are more stable and are felt with less intensity than emotions. Beliefs are cognitive constructions, which are very stable and difficult to change.

I view conceptions from Thompson’s perspective as “a more general mental structure encompassing beliefs, meanings, concepts, propositions, rules, mental images, preferences, and the like” (Thompson, 1992, p. 130). Thompson used this term in order not to distinguish between beliefs and knowledge. Yet, she gave a definition for knowledge. I view knowledge as “beliefs held with certainty or justified true beliefs” (Philipp, 2007, p. 281). Individuals can hold different beliefs with different levels of conviction. If someone holds a belief to be a fact, then the concept becomes knowledge to that individual.

Beliefs Framework

I adopted Ernest’s (1989) framework to classify beliefs. Ernest (1989) viewed teaching mathematics as depending on three key elements:

1. the teacher's mental contents or schemas, particularly the system of beliefs concerning mathematics and its teaching and learning;
2. the social context of the teaching situation, particularly the constraints and opportunities it provides; and
3. the teacher's level of thought processes and reflection (p. 249).

Ernest (1989) stated there were three different views of the nature of mathematics: the instrumentalist view, the Platonist view, and the problem solving view. Teachers who believed mathematics to be a set of rules and procedures were classified as having an instrumentalist view. Teachers with the Platonist view believed mathematics to be a unified, unchanging body of knowledge. Teachers with the problem solving view believed mathematics to be a man-made creation that is continually expanding.

The three categories identified by Ernest as beliefs about mathematics teachers' roles were instructor, explainer, and facilitator. Ernest (1989) described instructors as individuals who had a "narrow, instrumental and basic skills type view" (p. 250). The mathematics teachers who were classified as explainers believed in developing students' conceptual understanding of set mathematical concepts. Ernest described facilitators as teachers who believed in using problem solving in their classrooms to teach students to reason mathematically. Ernest also identified two different teacher views on student learning: passive recipients of knowledge or active constructers of knowledge.

Ernest (1989) explained, "These three philosophies of mathematics, as psychological systems of belief, can be conjectured to form a hierarchy" (p. 250). In this hierarchy, the instrumentalist view is the lowest level, and the problem solving view is the highest level. As shown in Figure 1, these three beliefs about the nature of mathematics were found to have significant correlation to teachers' beliefs about mathematics teaching and learning. Ernest suggested individuals who held a Platonist view of mathematics would be more likely to enact an explainer's role in the classroom and to view learners as passive recipients of knowledge (1989).

As I discussed earlier, beliefs can predict classroom practices, but there can also be other influences. Ernest (1989) justified his model in Figure 1, arguing:

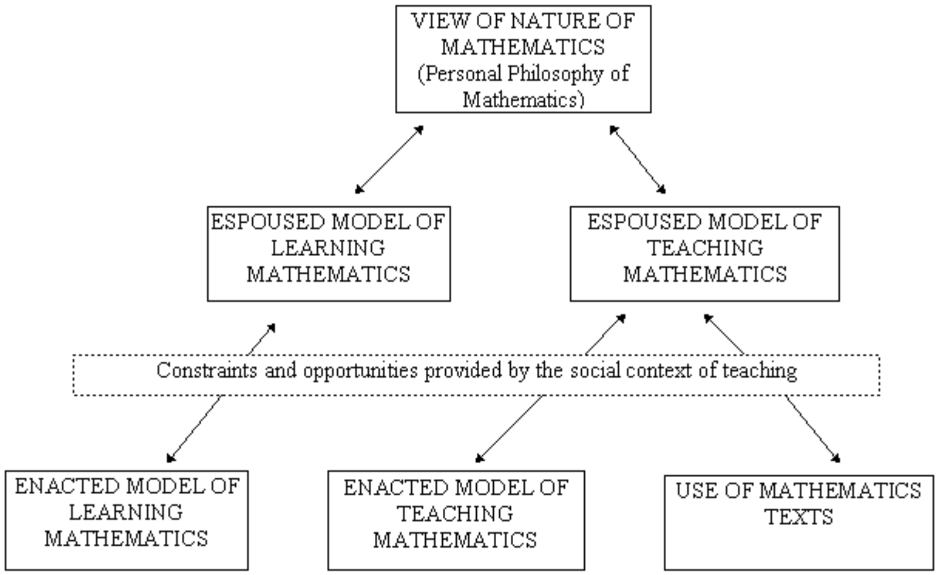


Figure 1. Ernest's (1989) relationship between beliefs and their impact on practices (p. 3).

> These are the enacted (as opposed to espoused) model of teaching mathematics, the use of mathematics texts or materials, and the enacted (as opposed to espoused) model of learning mathematics. The espoused-enacted distinction is necessary, because case-studies have shown that there can be a great disparity between a teacher's espoused and enacted models of teaching and learning mathematics. (p. 252)

Ernest did not view beliefs informing practices as a causal relationship because of two key factors. First, Ernest explained how social and cultural aspects such as a school’s environment and students’ behaviors could cause a change in teaching practice. Second, the level of teachers’ personal reflections could determine if they implement elements of their beliefs.

Beliefs Structure

According to Green (1971), beliefs have a quasi-logical structure. Green proposed that beliefs are affected by other beliefs; thus beliefs can be held in isolation and in groups. Philipp (2007) explained, “some beliefs serve as the foundation for other beliefs in a quasi-logical structure, meaning that some beliefs might be thought of as primary beliefs whereas others serve as derivative beliefs" (p. 260). Primary beliefs imply derivative beliefs, so the primary belief is the reason someone holds the derivative belief to be true. The relationship between beliefs was described as dynamic because modifications and new beliefs could be added into the structure. Green's quasi-logical structure gives us a way to show how individuals' beliefs relate to one another.

Sensible System of Beliefs

In my study, I viewed teachers' beliefs as being a sensible system (Leatham, 2006). In this sensible system, beliefs are viewed as influences on teachers' actions. However, it must be noted that just because teachers espouse or claim to believe a certain idea does not necessarily mean it was enacted in their classroom practices (Cooney, Shealy, & Arvold, 1998). Individuals often are not aware of their beliefs, so researchers must interpret participants' understanding using multiple strategies to ensure an accurate representation of their views (Cooney et al., 1998). If researchers find contradictory beliefs, they need to assume the inconsistencies exist in the minds of the researchers. As Leatham (2006) stated,

> When a teacher acts in a way that is consistent with the beliefs we have inferred, we have evidence that we may be on track, but we do not know what belief or beliefs the teacher was actually acting on at the time. When a teacher acts in a way that seems inconsistent with the beliefs we have inferred, we look deeper, for we must have either misunderstood the implications of that belief, or some other belief took precedence in that particular situation. (p. 95)

If we have accurately interpreted a teacher's beliefs, a contradiction between teacher's beliefs and classroom practices would not be observed. Individuals have beliefs about other demands that can change their mathematical teaching practice (Leatham, 2006). Thus, teachers may engage in practices that seem contradictory to their beliefs because they are prioritizing a belief about something other than mathematics teaching and learning. For example, a teacher might give a weekly timed multiplication test in their classroom even though they believe that students need to learn multiplication in a conceptual manner because they also believe that all students should know their multiplication facts before they enter the fourth grade. As long as other demands do not interfere, a link can be observed between teachers' beliefs and their classroom practices. I was mindful of Leatham's claim that teachers' beliefs are a sensible system and deliberately sought to discover other beliefs that participants may hold that do not pertain directly to the teaching and learning of mathematics.

Teachers' Beliefs and Teaching Practices

Researchers have searched for ways to influence teachers' beliefs to change teaching practices (Ambrose, 2004; Philipp, 2007; Stuart & Thurlow, 2000; Swars et al., 2007). Special mathematics methods classes have been studied to determine belief change (Philipp, 2007; Stuart & Thurlow, 2000) as well as specified field activities and failed teaching experiments (Ambrose, 2004). From these studies, the authors have come to some conclusions about how to affect teachers' beliefs.

First, teachers need to reflect on their current beliefs for a change to occur (Cooney et al., 1998; Kagan, 1992; Stuart & Thurlow, 2000). Activities such as keeping journals and writing autobiographies can foster personal reflection and initial belief change for teachers (Kagan, 1992; Stuart & Thurlow, 2000). However Vacc and Bright (1999) explained, "It is not clear whether pre-service teachers' education programs can structurally accommodate these needed 'reflection events'" (p. 107).

Second, beliefs are relatively stable and take significant time to be influenced (Cooney et al., 1998; Swars et al., 2007). Swars and her team of researchers determined that change was most significant after the second methods course, and preservice teachers either kept those beliefs or regressed to earlier beliefs during their student teaching (Swars, Smith, Smith, & Hart, 2009). Ambrose (2004) speculated that past beliefs might not be changed through teacher education programs, but rather individuals added new beliefs to their belief structure. Scott (2005) found that preservice elementary teachers at the beginning of their programs had similar experiences with traditional teaching practices in school as their graduating counterparts, but the graduating students had a greater likelihood of wanting to learn about and build on children's mathematical experiences. When practice and theory clashed, preservice teachers tended to be influenced by sources offering practical advice, for example practicing teachers (Scott, 2005). Forgasz and Leder (2008) explained:

> In many of the reports which contain positive accounts of functional changes in the prospective teachers' beliefs it was nevertheless concluded that the extent to which these changes would eventually be translated into practice in classrooms could only be a matter of speculation. (p. 179)

Third, after preservice teachers become practicing teachers, the research identified many obstacles occurring in the way of teachers enacting beliefs like:

1. Teachers' mathematical knowledge (Halai, 1998)
2. Students' classroom behavior (Steele, 2001)
3. Preconceived notions about students needs (Sztajn, 2003)
4. Teacher's everyday duties (Quinn & Wilson, 1997)

Overall, the researchers found that primary teachers who did experience belief change were subject to reflect on their own teaching practices, which did promote teachers to enact their beliefs in their classrooms (Clarke, 1997; Senger, 1998).

Fourth, the elementary teachers' mathematical content knowledge and locus of authority affect teaching practice. Teachers' confidence in their content knowledge and where they locate authority for instructional decisions influence the way they conduct themselves and their classrooms (Mewborn, 1999; Stipek, Givvin, Salmon, & MacGyvers, 2001). Building on Goodman's (1984) research on reflective thinking of preservice teachers, Mewborn (1999) found a relationship between preservice elementary teachers' locus of authority and the reflective quality of their thinking. Mewborn (1999) described authority as "something akin to permission or license" (p. 335). The locus of authority can be internal or external, depending on how the individual views who has permission to make decisions about classroom teaching practices. Mewborn found that preservice teachers were more likely to think reflectively when their locus of authority was internal.

Fifth, the way individuals see the world influences their mathematical beliefs (Pajares, 1992). Pajares (1992) stated that beliefs help individuals define and understand their world. Philipp (2007) followed this argument by explaining that "the way one makes sense of his or her world not only defines that person for the world but also defines the world for that person" (p. 257). This indicates that individuals' overarching beliefs can play a role in creating and defining their mathematics-specific beliefs. Thompson (1984) stated that many factors affect teachers' decisions and behavior, including beliefs about teaching that are not specific to mathematics. That is, overarching beliefs could play a significant role in affecting teachers' practice. When I describe overarching beliefs, I refer to psychologically held understandings about teaching and learning that do not necessarily pertain to mathematics.

Sixth, teacher educators generally strive to help preservice teachers experience mathematics learning in ways consistent with the reform movement in hopes of influencing their beliefs about mathematics teaching and learning. However, beliefs are not easily affected by teacher education programs (Hiebert, Gallimore, & Stigler, 2002; Hiebert, Morris, & Glass, 2003; Raymond, 1997). Hiebert et al. (2003) described their goals for teacher education as preparing preservice teachers to learn to teach for mathematical proficiency. They explained, "Even if the current knowledge base identified the complete set of skills and dispositions for effective teachers, it is unlikely that prospective teachers could acquire these competencies in a relatively brief preparation program" (Hiebert et al., 2003, p. 205). McDiarmid (1990) constructed a course to have students reconsider their beliefs, but he stated:

> Yet, despite abundant evidence that prospective teachers do reconsider their initial beliefs and orientations, that they begin to understand the folkways of teaching they have learned are not merely unreflective but, in some respects, downright damaging, I am skeptical about the effects of the course. (p. 20)

Hiebert et al. (2002) explained one reason for this disconnect between practices reinforced in teacher education programs and practices implemented in schools comes from a lack of communication between educational researchers and school practitioners. Because of this disconnect and lack of changing traditional beliefs, many researchers found that the teacher education program had a minimal impact on the preservice teachers' beliefs (Raymond, 1997; Hiebert et al., 2002).

Seventh, research has shown that primary teachers hold similar beliefs (Archer, 2000; Seaman, Szydlik, Szydlik, & Beam, 2005). Archer (2000) reported that primary teachers consistently hold beliefs about mathematics corresponding to how the subject relates to everyday life experiences. Forgasz and Leder (2008) wrote, "The primary teachers' views were considered consistent with the holistic approach of primary education" (p. 182); thus primary teachers emphasized the connection to real life situations because they believed they missed this connection when they were students. However, Beswick (2005) found few teachers held beliefs about the nature of mathematics that could be classified by Ernest's problem solver's view.

Factors that Influence Beliefs

Mathematics education researchers have investigated many different aspects of the factors affecting teachers' beliefs (Borko et al., 1992; Raymond, 1997; Richardson, 1996). Borko et al. (1992) described factors influencing the process of learning to teach. Raymond (1997) investigated preservice teacher's construction of beliefs, and Richardson (1996) described general factors influencing teachers' beliefs. However, the literature has only speculated about what factors could affect belief construction over time.

Borko et al. (1992) conducted a study hypothesizing that specific factors would be the major sources of external influence on teachers' processes of learning to teach. As shown in Figure 2, they identified the factors as personal history, university experiences, individual participant's knowledge and beliefs, individual's classroom thinking and actions, involvement in the research project, and public school experiences as influences on teachers' mathematical teaching practice (Borko et al., 1992). The authors did not claim these factors influenced beliefs, but they did view them as having an influence on how teachers come to understand how to teach mathematical concepts.

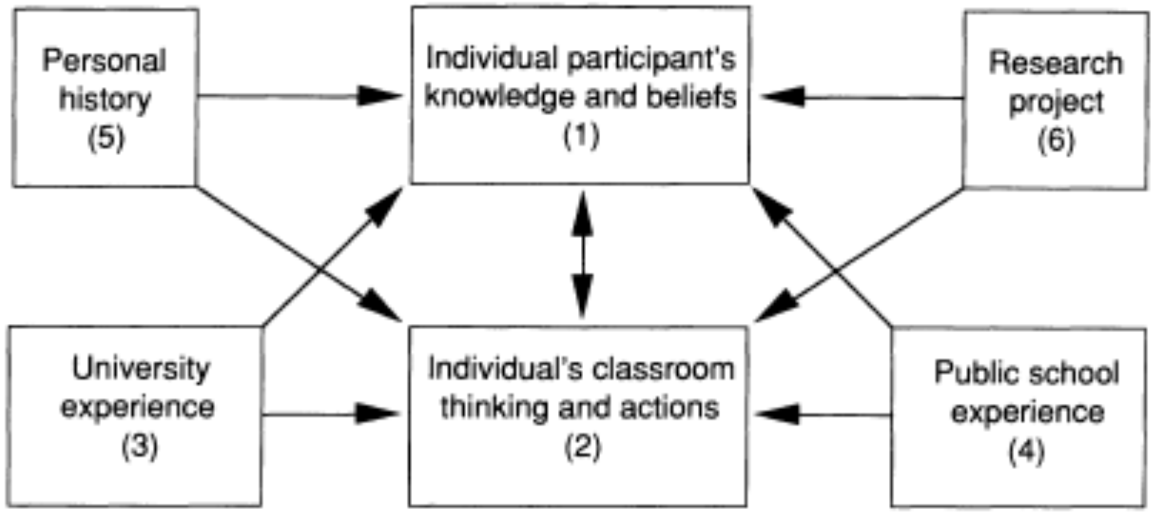


Figure 2. Borko et al.'s (1992) model of becoming a mathematics teacher (p. 200).

To classify the influences on individuals' beliefs in my study, I used a combination of Raymond's (1997) framework of influences on teacher beliefs and practices and Richardson's (1996) influences on beliefs. Raymond investigated first- and second-year elementary teachers' mathematical beliefs and mathematical teaching practices, and explored teachers' beliefs about the nature of mathematics, learning mathematics, and teaching mathematics as well as the teacher's mathematics teaching practices. She concluded that the teacher's beliefs about the nature of mathematics correlated more strongly with her teaching practices than did her beliefs about learning or teaching. She suggested that education programs help preservice teachers become aware of their beliefs about the nature of mathematics at the beginning of their programs to allow them time to reflect and develop more productive beliefs about learning and teaching (Raymond, 1997). She proposed a possible model to explain the interaction of the factors affecting beliefs and teaching practices in the classroom as shown in Figure 3. I used this model to help me identify factors affecting beliefs and practices.

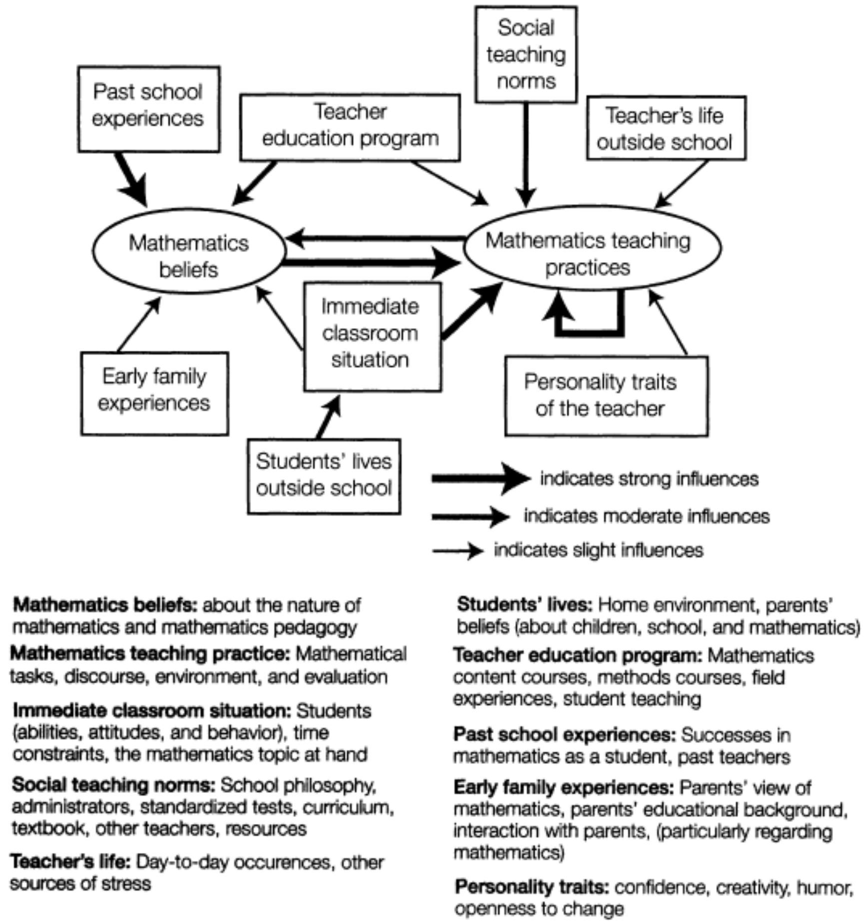


Figure 3. Raymond's (1997) revised model of relationships between mathematics beliefs and practice (p. 571).

As shown in Figure 4, Richardson (1996) identified factors affecting belief change and categorized them into three different sections: personal experiences, experiences with schooling and instruction, and experience with formal knowledge. Clandinin (1986), Clandinin and Connelly (1991), and Doyle (1990) investigated the first factor of personal experience. Clandinin and Connelly (1991) and Clandinin (1986) determined that individual personal history affects the teacher's view and understanding of the world, self, society, and culture. Doyle (1990) claimed personal experience to be the most influential in the teacher's belief formation. Beliefs constructed from personal events were found to be stable, difficult to change, and good predictors of teaching practices implemented in the classroom (Doyle, 1990).

Seaman et al. (2005), Lindgren (2000), and Guskey (1986) investigated the second factor consisting of the teachers' experiences as both students and teachers. Seaman et al. (2005) found teachers' beliefs were directly impacted by their past schooling experiences, and that teachers connect their experiences as students with what they should teach as teachers. Lindgren (2000) found that teachers who experienced less traditional schooling experiences had differing beliefs from individuals who had traditional experiences. Guskey (1986) identified teachers' classroom teaching experiences as a determining factor in the construction of beliefs. Guskey believed that belief change would only occur after evidence was given to support the reformed belief. However, Grant, Hiebert, and Wearne (1998) found beliefs filtered what teachers internalize; thus, if teachers did not believe in the practice, what they observe might not change their teaching practice.

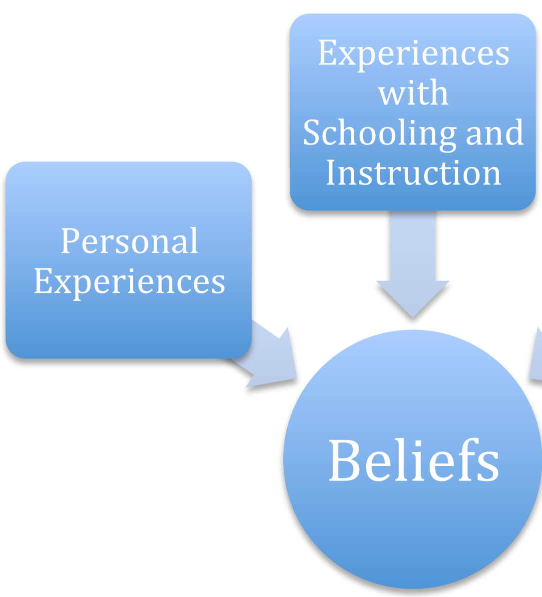


Figure 4. Richardson's (1996) factors affecting belief change.

Crow (1987) and Leinhardt (1988) investigated the third factor of experience with formal knowledge. Richardson's (1996) final factor forked into two different areas: content knowledge and pedagogical knowledge. Leinhardt (1988) suggested that content knowledge development predicted mathematical beliefs, and she claimed that teachers' experiences with different types of mathematics problems as students and as teachers affected their beliefs about the nature of mathematics and their instructional practices. Crow found that pedagogical knowledge gained from teacher education programs or teaching experiences affected teachers' beliefs as well (1987). However, as Richardson (1996) stated, "Experiences with formal pedagogical knowledge are shown as the least powerful factor affecting beliefs and conceptions of teaching and the teacher's role" (p. 106).

Because these two models of Raymond (1997) and Richardson (1996) are different, I constructed my own model, as shown in Figure 5, melding both models. The categories of factors that affect beliefs that I identified in my initial model are:

1. Personal Experiences (past and present events that occurred outside of school)
2. Schooling Experiences (past events that occurred in K-16 schools outside of their teacher education program)
3. Teacher Education Experiences (past and present events that occurred in a teacher education program, graduate program, or professional development experience)
4. Teaching Experiences (past and present events while teaching students in the school environment).

The four categories were formed from Raymond's factors and Richardson's three factors: personal experiences, experience with schooling and instruction, and experience with formal knowledge. Personal experiences maintained its category, but experience with schooling and instruction was divided into three different areas: schooling experiences, teacher education experiences, and teaching experiences. Also, because formal knowledge is gained from personal experiences and experiences with schooling and instruction, I viewed formal knowledge as included in my four categories.

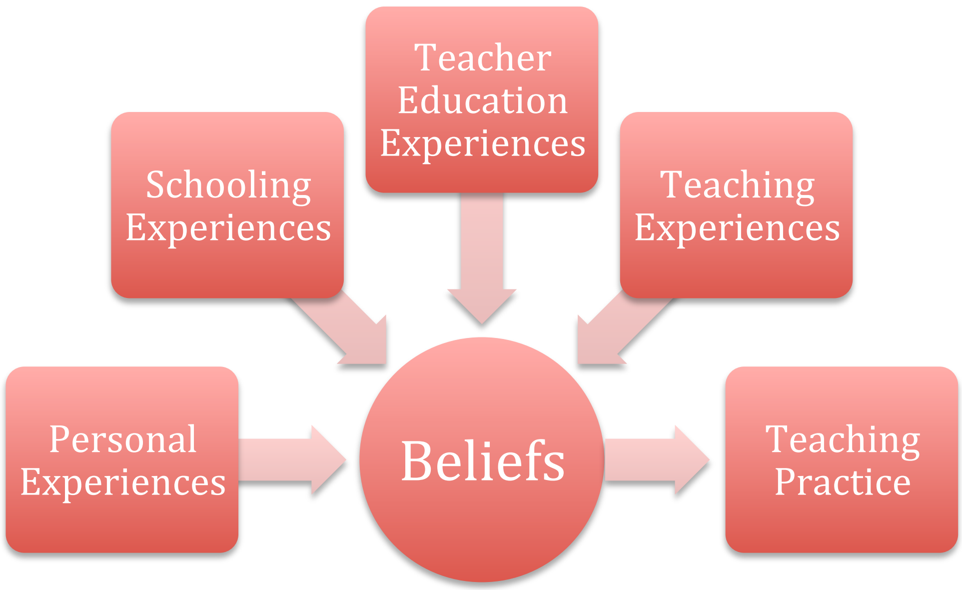


Figure 5. Initial model of factors affecting beliefs.

Raymond's (1997) factors affecting beliefs (past schooling experiences, teacher education program, early family experiences, and immediate classroom situation) could be mapped to my four categories. Past schooling experiences are included in category two, schooling experience. Teacher education program can be classified under teacher education experience in category three. Early family experiences are included in personal experiences in category one, and immediate classroom situations could be included in teaching experience in category four.

Other Relevant Literature

From my data analysis I identified factors that affected the elementary teachers over time. First, teachers' new roles as educators, wives, and mothers affected their beliefs and teaching practices. Next, the teachers' personality traits influenced beliefs about the nature of mathematics, teaching mathematics, and learning mathematics. Finally, the participants identified the economic situation as a powerful factor affecting how they taught their students. In this section, I explore some literature related to the factors of teachers' roles, professional identity, and economic situations.

Teachers' Roles

Day, Sammons, Stobart, Kington, and Gu (2007) and Day, Sammons, Gu, Kington, and Stobart (2009) studied the relationship between teachers' commitment, resilience, and effectiveness, and determined specific factors that influenced these traits as shown in Figure 6. The authors' research identified teachers' identity as a combination of competing interactions between personal, professional, and situational factors. Professional factors represented the individuals' work life, from their personal workload and their roles and responsibilities at the school to their beliefs about "good" teaching. Situational factors included the individuals' socially located identity in their school, department, or classroom. Personal factors included the individuals' lives outside of school such as identity as a mother, wife, or daughter. Teachers navigated between these three identities, "affecting their sense of vulnerability, well-being, agency, and effectiveness" (Day et al., 2007, p. 108).

Professional Identity

Day et al. (2007) identified two moderating factors influencing teachers' formation of their identity: professional life phases and professional identity as shown in Figure 6. Huberman (1993) identified 6 career phases as experienced by middle school and high school teachers:

- Phase 1: 0–3 years – Commitment: Support and challenge.
- Phase 2: 4–7 years – Identity and efficacy in the classroom.

- Phase 3: 8–15 years – Managing changes in role and identity: Growing tensions and transitions.
- Phase 4: 16–23 years – Work–life tensions: Challenges to motivation and commitment.
- Phase 5: 24–30 years – Challenges to sustaining motivation.
- Phase 6: 31 + years – Sustaining/declining motivation, coping with change and looking to retire.

Day et al. (2009) investigation identified a connection between Huberman's phases and effectiveness of teachers stating, "those in their later years of teaching were more 'at risk' in terms of their effectiveness than those in early and middle phases" (p. 61).

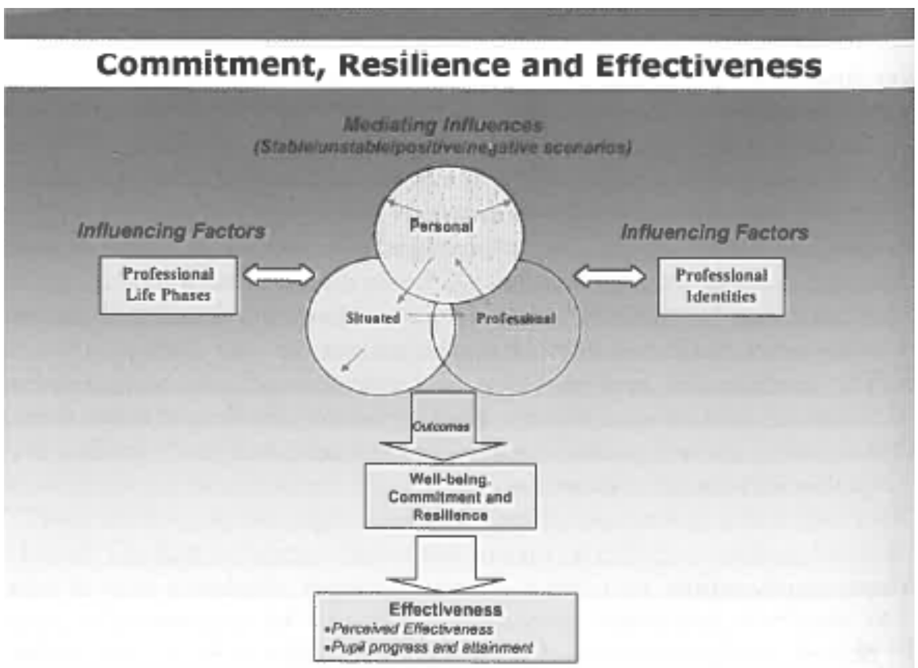


Figure 6. Day et al.'s (2007) model of commitment, resilience, and effectiveness (p. 238).

Cochran-Smith et al. (2012) stated, "teachers' emotional identities and school contexts were central moderating influences at all life phases on teacher effectiveness, commitment, and resilience" (p. 848). The teachers' personality traits influenced teachers because, "knowledge of the self is a critical element in the way teachers construe and construct the nature of their work and that events and experiences in the personal lives of teachers are intimately linked to the performance of their professional roles” (Day et al., 2009, p. 57). Day and Sachs (2004) found a positive sense of identity was needed to sustain teachers’ self-confidence, self-efficacy, and continued commitment in the field.

Recession

Studies investigating the impact of economic situations such as the recession have focused on how it affects teachers’ incomes rather than how it affects teachers’ teaching practices. By recession, I mean, “a general slowdown in economic activity, a downturn in the business cycle, a reduction in the amount of goods and services produced and sold” (Bureau of Labor Statistics, 2012, p. 2) which occurred in the United States between 2007 and 2009. With such titles as, “Teaching: No longer a Recession-Proof Job” (Luhby, 2010), “Will Teaching Face a Recession” (Bureau of Labor Statistics, 2008), “The Recession’s Impact on Teachers’ Salaries” (National Council of Teacher Quality, 2013), and “Recession Upended Teachers' Dreams, Created A 'Triple Tragedy' In Schools and Education” (Collins, 2011), the media has documented the impact of the recession on teachers’ incomes because the career was once thought of as a secure profession. Collins (2011) wrote, “But the Great Recession and its ripple effects on the state and local tax dollars that fund public schools have upended the conventional wisdom that a teaching job is a golden ticket to career stability” (p. 1). The media has noticed that teachers’ income has been influenced, but the consequences for teachers’ practices have not been investigated.

As shown in Figure 7, the recession caused the nation’s unemployment rate to peak to 10 percent, which was the largest spike in unemployment since 1982’s stock market crash, and caused the highest recorded percentage of individuals suffering from long-term unemployment.

The U.S. Bureau of Labor Statistics (2012) reported, “The employment decline experienced during the December 2007–June 2009 recession was greater than that of any recession of recent decades” (p. 7). Thus, the recession had a widespread influence on millions of families.

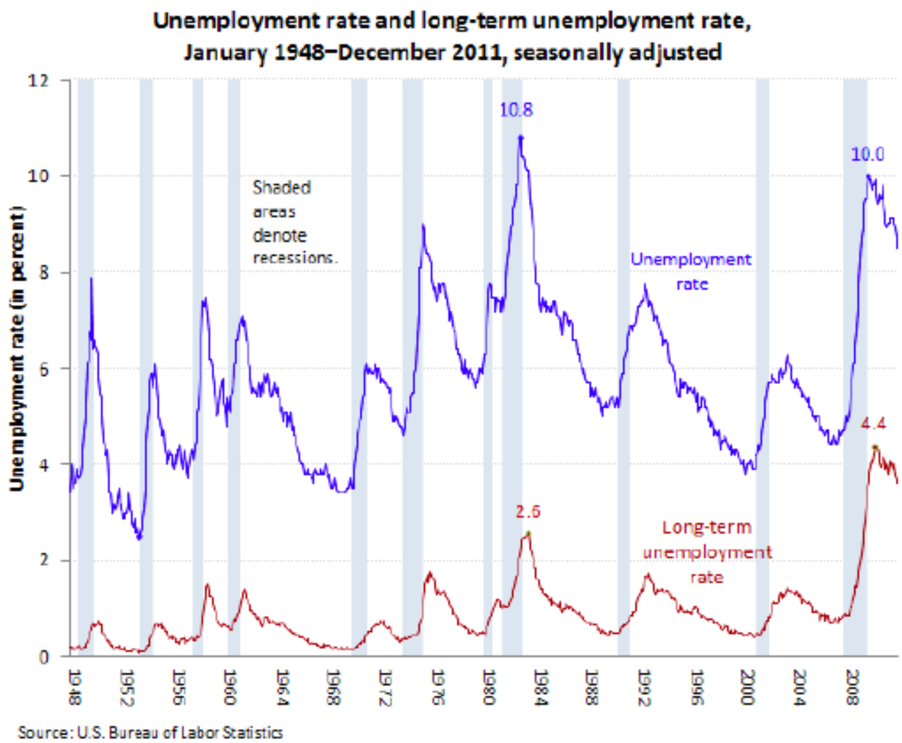
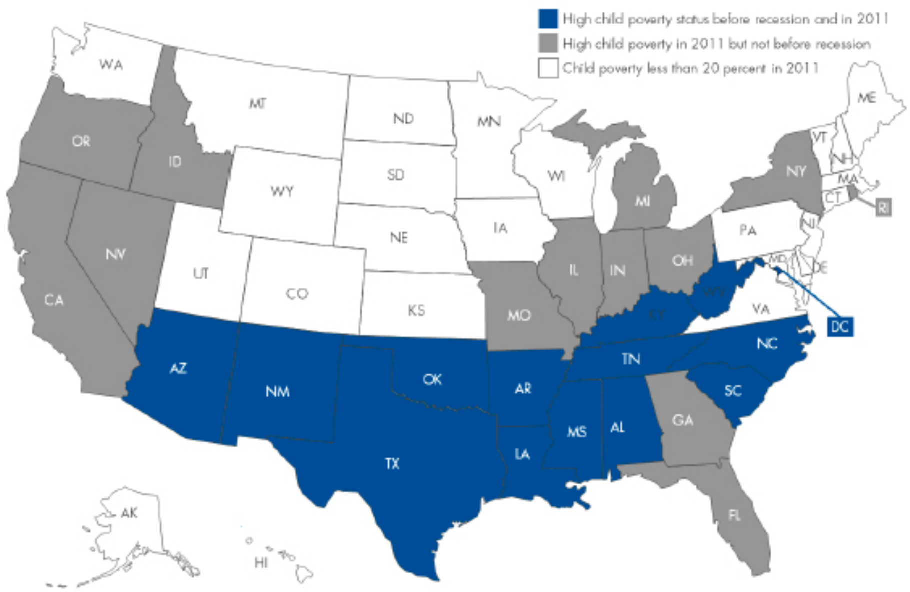


Figure 7. Unemployment rate from 1948-2011 for the United States (BLS, 2012, p. 3).

Because many parents were out of work and could not find employment for extended periods, the United States experienced an increase in the number of children living in poverty. As shown in Figure 8, the Urban Institute (2012) reported that in Georgia (the state in which this study was conducted), over 20 percent of children were living in poverty, higher than before the recession. As of the Urban Institute’s 2012 report, the overall pictures for many families had not changed since the start of the recession. It explained, “The economy has begun its slow recovery, but hard economic times are not over for millions of children and families” (p. 14). Because parents were subjected to mass layoffs, the student populations of many schools changed during this time, reflecting this economic downturn.

Thus, as a result of the recession, the student populations in teachers' classrooms changed in one of two ways. Either the students remained the same while their economic situations changed, or the student population changed due to students moving. Both types of change affected the teaching practices of participants in this study.

Child Poverty Is More Widespread After the Recession



Note: High child poverty status is defined as having a child poverty rate of 20 percent or higher. Poverty before the recession is measured over the 2000–2007 period.

Figure 8. Urban Institute's (2012) figure of how child poverty has increased since the recession (p. 2).

CHAPTER 3

METHODOLOGY

The data for this investigation were collected over a four-month period to address the following questions:

1. What are the elementary teachers’ teaching practices and beliefs about the nature of mathematics, teaching mathematics, and learning mathematics after 10 or more years of teaching?
2. How have these elementary teachers’ beliefs about the nature of mathematics, teaching mathematics, and learning mathematics changed since their second year of teaching?
3. What factors contributed to the formation of these beliefs?

Pajares (1992) warned about the difficulties of determining individuals’ beliefs. Pajares (1992) stated:

> Making inferences about individuals' underlying states [is] fraught with difficulty because individuals are often unable or unwilling, for many reasons, to accurately represent their beliefs. For this reason, beliefs cannot be directly observed or measured but must be inferred from what people say, intend, and do—fundamental prerequisites that educational researchers have seldom followed. (p. 314)

Thus, to infer my participants’ beliefs through what they said, intended, and did, I collected data using multiple strategies. Using methodological triangulation of four interviews, two surveys, and three classroom observations, I investigated the individuals’ beliefs and factors influencing those beliefs and had the participants validate my findings.

Participants

I sampled my participants from a previous study on teachers' beliefs. In that study titled Learning to Teach Elementary Mathematics, two cohorts of elementary education students were followed through 2 years of their teacher education program and into their first 2 years of teaching. At the start of the study, the participants were in their junior year of college and had completed one mathematics content course for elementary education majors. During the study, they completed 2 mathematics methods courses for elementary education majors under the instruction of the teacher with the pseudonym Dr. Mathis, the first of which included a mathematics-specific field experience. In their second and third semesters, they participated in 4-week field experiences in local schools. Their final semester of the teacher education program consisted of a traditional student teaching experience. After they graduated, the participants were hired at elementary schools, and they were followed through their first two years of teaching.

Across the initial 4 years of the study, the teachers participated in interviews, classroom observations, and completed the Integrating Mathematics and Pedagogy (IMAP) belief survey (Philipp et al., 2007). Table 1 displayed the number of interviews, observations, and surveys each participant took part in. In addition, the researchers had access to all of the participants' written work, such as their autobiographies, homework assignments, and lesson plans from their 2 methods courses.

Table 1

Data Collected from the Learning to Teach Elementary Mathematics Teachers Study

Data	Laura	Jayne	Jennifer
Interviews	6	7	6
Classroom Observations	5	7	8
IMAP Belief Surveys	1	1	1

From the Learning to Teach Elementary Mathematics Teacher Study, Spangler et al. (2012) identified that pedagogical coursework and field experiences changed some preservice teachers' beliefs. I wanted to determine if this change lasted over time and what factors contributed to maintaining or changing these beliefs.

I chose three of the fifteen participants with pseudonyms Laura, Jayne, and Jennifer from the original study to investigate how their beliefs had changed since the end of the initial study. As shown in Table 2, I selected Laura, Jayne, and Jennifer because they displayed three different patterns of belief development during the prior study (Spangler et al., 2012).

Table 2

Participants' Beliefs From Spangler et al. (2012)

	Stage	Laura	Jayne	Jennifer
Belief about the Nature of Mathematics	Initial	Instrumentalist	Platonist	Instrumentalist
	Second Year	Platonist	Problem solving	Instrumentalist
Belief about Mathematics Learning	Initial	Passive	Active	Passive
	Second Year	Active	Active	Active
Belief about Mathematics Teacher's Role	Initial	Instructor	Explainer	Explainer
	Second Year	Facilitator	Facilitator	Explainer

Laura began her educational experience with an instrumentalist view of mathematics, a belief that teachers should assume an instructor's role in the classroom, and a belief in passive learning. She grew through her educational and teaching experiences in all of her beliefs. By the second year of teaching, she became a Platonist who demonstrated a facilitator's role in the classroom and believed in students actively constructing knowledge.

Jayne began her educational experience believing students actively learn mathematics. She held a Platonist view of mathematics and viewed the teacher's role as that of an explainer.

With an overarching belief about students' abilities to think deeply, by her second year of teaching, she progressed to hold a problem solver's view of mathematics and to assume a facilitator role in the classroom.

Jennifer began her educational experience as an instrumentalist who held a view that teachers should be explainers in the classroom and believed in students passively learning. Jennifer did not experience any change in beliefs from her teacher education program and ended her second year of teaching with the same beliefs.

The three participants were white females in their early 30s. They taught for at least 10 years and were teaching in schools in the same southeastern state at the time of this study.

Across the 10 years, Laura taught in the same district in two different schools. She taught at an elementary school for 4 years in fourth grade, and she taught at a primary school for 6 years, 5 of which were in first grade and one of which was in kindergarten. Her elementary school had Title 1 status since 2003 and experienced an increase in the number of students eligible for free and reduced lunch across the 10 years as shown in Figure 9. During the 10 years, she earned her master's degree in Early Childhood Education, was married, and had two children. During the semester I observed her class, she was a first grade teacher with a class consisting of 7 white students, 9 Hispanic students, and 3 African American students.

Since leaving her teacher education program, Jayne taught first grade in the same school for 11 years, experiencing change in both her community and students. Her school gained Title 1 status in the 2007 - 2008 school year, and the school's students eligible for free/reduced lunch had drastically increased each year since 2003. During that time, she was married, had two children, and earned a master's degree in Early Childhood Reading and Literacy. I observed her first grade class consisting of 3 white students, 5 Hispanic students, and 12 African American students.

Over the 10 years, Jennifer lived in three different states, teaching elementary school in second through fifth grade. She was married, had a child, earned a master's in Curriculum and Instruction, earned a specialist in Educational Leadership, experienced job transfers, was divorced, and moved back to her home state. During this study, she taught at the same school she taught in during her first year of teaching. The school had a decreasing trend in the percentage of students eligible for free/reduced meals as shown in Figure 9. The semester she was observed, she was the fifth grade mathematics teacher for the school. I observed her teaching one of her fifth grade classes consisting of 17 white students and 3 Hispanic students.

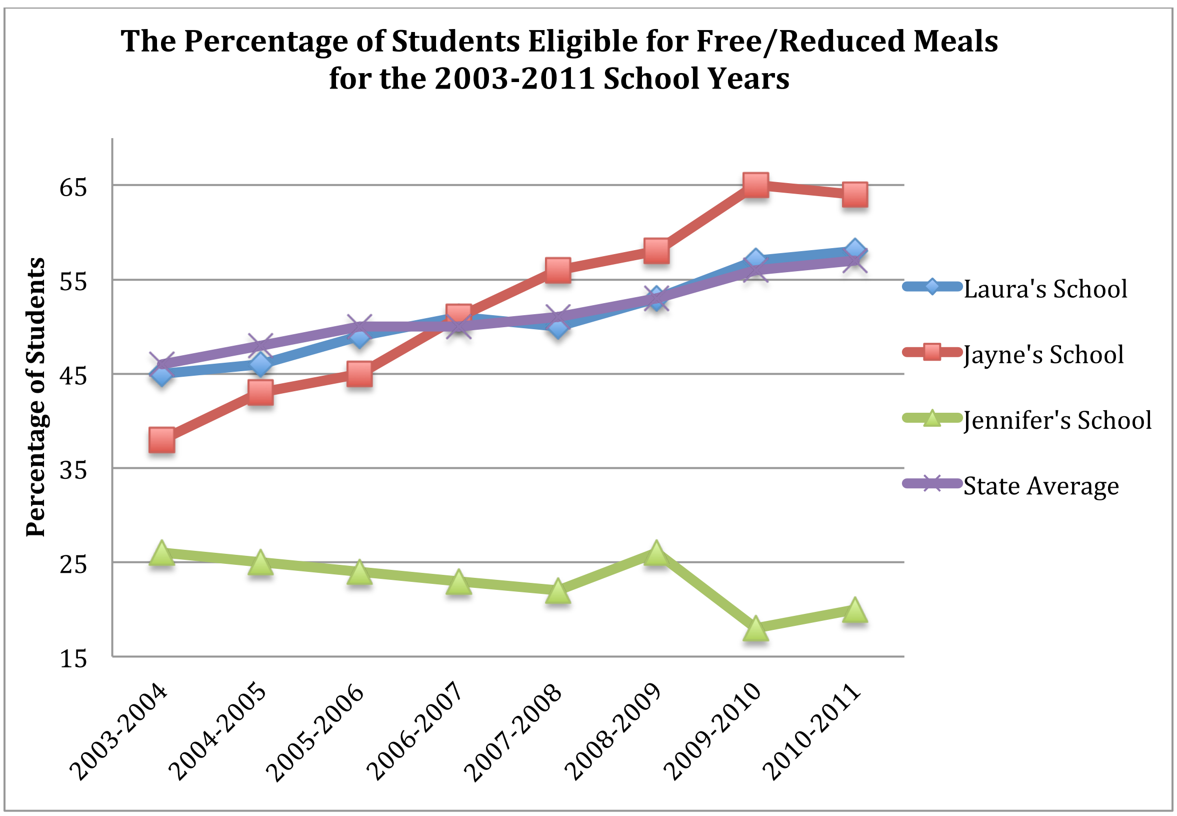


Figure 9. The percentage of students eligible for free/reduced price meals for the 2003-2011 school years (Georgia Department of Education, 2014).

Georgia's educational environment underwent many developments across the 10 years. Prior to the participants entering the teaching profession, the Quality Basic Education Act of 1985 required the state to maintain a curriculum that specifies standards for instruction resulting in the construction of the Quality Core Curriculum (QCC) (Georgia Department of Education, 2013). In 2001, No Child Left Behind Act (NCLB) changed the landscape of elementary and secondary education by requiring states to assess students through standardized tests to receive federal funding. NCLB identified consequences to schools receiving Title 1 funds that repeatedly had poor performance on the standardized tests. In response, the QCC was audited by Phi Delta Kappa in 2002 and was deemed insufficient. In 2003, the same year the participants entered the work force, the Georgia Performance Standards (GPS) were created to meet national standards. In 2010, Georgia Board of Education adopted the Common Core State Standards, spawning the construction of the Common Core Georgia Performance Standards (CCGPS). CCGPS was a revised version of the GPS to include the Common Core Standards. In 2014 - 2015 school year full implementation of the CCGPS will take effect (Georgia Department of Education, 2013).

Data Collection

I collected data on each individual by conducting:

1. three face-to-face interviews
2. one focus group meeting with all participants
3. three 1-hour classroom observations
4. Integrating Mathematics and Pedagogy (IMAP) Belief Survey (Philipp et al., 2007)
5. Known Factors Affecting Mathematical Belief Change (KFABC) Survey

Data collection proceeded as follows. First, I conducted an initial hour-long classroom observation of each teacher. Next, I asked each participant to complete the IMAP Belief Survey and the KFABC Survey. Based on the data from her KFABC Survey, I created the second interview protocol focusing on the factors affecting the individual's beliefs. I completed the second classroom observation a week later. During the same visit, I conducted the second interview, asking about different influences on their mathematical beliefs as well as discussing the second lesson that was observed and how it related to their beliefs. Next, I coordinated the focus group interview and the third classroom observation. I conducted an initial analysis of the data to construct a story of each participant's change over time and presented my participants with a copy of my interpretation. Finally, I conducted the third interview as a member check. In this interview, I gave the participants the opportunity to respond to my interpretation of their beliefs and asked them to compare their beliefs after their second year of teaching to what they currently believed.

Instruments Used to Collect Data

Table 3 shows how each aspect of data collection was used to answer one or more of my research questions. In this section, I explain why I collected each form of data and how I constructed the protocols for each item.

First Interview

The purpose of the first interview was to elicit the teachers' current beliefs. In the first interview, I asked 9 different questions, each related to the individual's mathematical beliefs (Appendix A). Most individuals are not aware of their beliefs (Cooney et al., 1998; Thompson, 1992) so Cooney et al. created similes to help stimulate discussion about what individuals believe about mathematics. I used two of their similes in my first interview to help teachers articulate their beliefs.

Table 3

Connections Between the Data Sources and Research Questions

Research Questions	Interviews	Focus Group	Classroom Observations	IMAP Belief Survey	KFABC Survey
What are elementary teachers' teaching practices and beliefs about the nature of mathematics, teaching mathematics, and learning mathematics after 10 years of teaching?	Interviews 1 and 3 focused on identifying the teachers' current beliefs and validating my interpretation of their beliefs.	During discussions about factors, teachers identified beliefs.	I observed teaching practices and looked into how teachers' beliefs manifested in their teaching practices.	The IMAP Belief survey helped determine their beliefs.	
How have these elementary teachers' beliefs about the nature of mathematics, teaching mathematics, and learning mathematics changed since their second year of teaching?	Interview 3 focused on how beliefs have changed since their second year of teaching.	During the discussion, teachers identified past and present beliefs and discuss how they compared.	I observed teaching practices and looked into connection with teachers' beliefs. Also, I compared these practices to their second year teaching practices.	The IMAP Belief survey helped determine their current beliefs, and I compared this data to their original IMAP survey.	
What factors contributed to the formation of these mathematics beliefs?	Interview 2 focused on identifying and ranking factors in teachers' lives.	The focus group interview centered on what influenced their belief change as a group.			The KFABC survey is an open-ended questionnaire determining factors affecting belief change.

1. Learning mathematics is like:

- Working on an assembly line
- Cooking with a recipe
- Working a jigsaw puzzle
- Watching a movie
- Picking fruit from a tree
- Conducting an experiment
- Creating a clay sculpture
- Other

2. A mathematics teacher is like a:

- News broadcaster
- Doctor
- Gardener
- Entertainer
- Orchestra conductor
- Coach
- Social worker
- Other

As suggested by Cooney et al. (1998), I was interested in the participants' explanations of each simile rather than the particular simile they picked.

The last seven questions from the first interview were based on questions from my pilot study investigating the beliefs of an experienced elementary teacher. Three questions asked the teachers how they would use specific mathematical tasks in their classrooms. Each problem came from an article by Smith, Stein, Arbaugh, Brown, and Mossgrove (2004) on cognitively demanding tasks for elementary teachers. By asking the teachers how they would use a similar task in their classrooms, I explored the teachers' views of the nature of mathematics as well as how to teach mathematics to their students. Because the three questions represented different levels of cognitive demand, I gained insight into the importance they placed on these kinds of tasks in their classrooms. The teachers also watched videos of a classroom and students responding to mathematical problems and I asked them:

1. What is your view of this teacher's role in her classroom?

   Probing Questions: What did she do well in her classroom? What would you change?

2. How would you teach this lesson in your classroom?

Probing Question: Would you teach the lesson differently?

From their responses to the videos, I inferred their views about students' learning and the teacher's role in the classroom. The last two questions asked the teachers to judge the difficulty of tasks and how students might respond to tasks. This helped me infer their views about the nature of mathematics and the teacher's role.

Second Interview

I constructed the second interview to investigate the factors contributing to the formation of the teachers' beliefs. I used open-ended questions and directed questions to elicit influences on teachers' beliefs (see Appendix B). These questions were constructed from responses individuals gave in the first interview as well as their responses to the KFABC survey. While answering questions in the first interview, the participants alluded to events and people who helped them construct their personal understanding of the nature of mathematics, teaching mathematics, and learning mathematics. Also, the data from their KFABC surveys directed me to events that affected the individuals' belief change. Finally, I asked the participants to rank the importance of the factors in their development to obtain a better understanding of their views of the relative importance of the factors.

Third Interview

The third interview gave the participants the opportunity to explain how they viewed a connection between the factors influencing their beliefs and the construction of their beliefs (as shown in Appendix C). From the responses to the second interview, I constructed additional questions to understand how they viewed the influences on their beliefs. From these data as well as the previous data collected on the individuals' beliefs and factors, I constructed a document explaining my initial analysis. I sent each participant the document by email. By giving my participants my initial interpretation of the data, I was able to obtain confirmation of the validity of my findings. After the participants read the stimulus text, they confirmed my interpretation of their beliefs or suggested modifications either through a phone interview or by email. All three participants confirmed that they agreed with my initial interpretation of their beliefs and factors affecting beliefs, and only minor corrections were made to address inaccuracies about the individuals' work histories or statements given during interviews.

Focus Group Interview

Because the individuals in my research study came from the same undergraduate preparation program, they had a common experience that allowed for meaningful dialogue in a focus group. During the focus group interview I asked the participants about their experiences in their mathematics methods classes and probed how they interpreted these experiences (as shown in Appendix D). I also asked them to discuss activities or events that all four of them had mentioned in previous interviews and surveys (such as a field experience associated with one of their methods courses) to see the similarities and differences in the ways they interpreted these events. I was also interested in how they responded to each other's comments about factors affecting their change over time to identify similarities and differences in their experiences.

Classroom Observations

Beliefs are asserted to be a strong predictor of classroom practice (Cross, 2009), so I used classroom observations to help me infer my participants' beliefs. Leatham (2006) argued that beliefs are constructed in a sensible system for each teacher even if they do not appear sensible to an outsider, so when I found a contradiction between a person's beliefs and practices, I continued investigating to better understand the participant's perspective.

During my classroom observations I focused on the richness of the mathematics, the role each participant took as a mathematics teacher, and the role the students took in the classroom (Hill et al., 2008). I chose to focus on richness, teachers' role, and students' role in the mathematics classroom based on the results of Hill et al.'s (2008) article shown in Figure 10. With this information, I identified the practices that were enacted in their classrooms, and I determined how these practices were similar to or different from those of their second year of teaching (Hill et al., 2008).

Elements of Mathematical Quality of Instruction

- Mathematics errors—the presence of computational, linguistic, representational, or other mathematical errors in instruction;
  - Contains subcategory specifically for errors with mathematical language
- Responding to students inappropriately—the degree to which teacher either misinterprets or, in the case of student misunderstanding, fails to respond to student utterance;
- Connecting classroom practice to mathematics—the degree to which classroom practice is connected to important and worthwhile mathematical ideas and procedures as opposed to either non-mathematical focus, such as classroom management, or activities that do not require mathematical thinking, such as students following directions to cut, color, and paste, but with no obvious connections between these activities and mathematical meaning(s);
- Richness of the mathematics—the use of multiple representations, linking among representations, mathematical explanation and justification, and explicitness around mathematical practices such as proof and reasoning;
- Responding to students appropriately—the degree to which teacher can correctly interpret students' mathematical utterances and address student misunderstandings;
- Mathematical language—the density of accurate mathematical language in instruction, the use of language to clearly convey mathematical ideas, as well as any explicit discussion of the use of mathematical language.

Figure 10. Elements of Mathematical Quality of Instruction (Hill et al., 2008, p. 437).

To ensure consistency in my observations across time and across participants, I used the Mathematical Quality of Instruction (MQI) observation protocol during the observations. The MQI allows the observer to capture, "a composite of several dimensions that characterize the rigor and richness of the mathematics of the lesson, including the presence or absence of mathematical errors, mathematical explanation and justification, mathematical representation, and related observables" (Hill et al., 2008, p. 431). To insure that I was using the instrument reliably, I was trained to use the instrument and completed a certification exam, which involved scoring 80 minutes of instruction within 80 percent accuracy. Prior to using the instrument for this study, I had over 30 hours of experience observing video tapes of elementary classrooms with this rubric as part of another project, and I participated in weekly calibration meetings to insure my scoring was consistent with creators' intention for each dimension. I used the MQI during my observations (Appendix E) to record what happened in the classroom as I was not allowed to video tape observations.

Instruction was broken into 7-minute segments, and each element of MQI was scored based on what occurred during those 7 minutes. The segments were coded using a 3-point scale from 1 to 3. The segment was scored a 1 if the element either was not observed or was observed with low frequency. The segment was scored a 2 if the element was observed but did not include all the areas described in the element in the 7-minute instructional period. The segment was scored a 3 if the element was present with high frequency featuring each aspect of the element. For example, a teacher can score a 3 in Linking and Connections if the teacher is explicitly connecting two or more ideas, procedures, or representations across the 7-minute section. The same teacher can score a 3 in Imprecision in Language or Notation if he or she frequently produces major mathematical notational or linguistic errors during a section.

I also took field notes during my observations to flesh out the items captured by the MQI. Following the observation, I used the MQI data and my field notes to link specific aspects of classroom practice to beliefs expressed by the teacher.

Known Factors Affecting Belief Change Survey

As shown in Appendix F, I developed the Known Factors Affecting Belief Change (KFABC) Survey to collect data about the participants' backgrounds. Research in mathematics education identified some influences that could affect belief development (Raymond, 1997; Richardson, 1996), and I coupled these findings with a pilot study I conducted to create the survey. To ensure validity and reliability, I tested the instrument with twelve former teachers and had the group help to analyze the data to determine if the instrument collected data it was designed to find. The KFABC survey was a web-based 20-item open response questionnaire, which took about an hour to complete.

Integrating Mathematics And Pedagogy Belief Survey

The Integrating Mathematics And Pedagogy Belief Survey (IMAP, Philipp et al., 2007) is a web-based survey that includes video clips, open response questions, and written teaching episodes. The survey allows for branching based on early responses given by a participant to capture more fine-grained beliefs than would be possible by administering the identical instrument to all participants. The IMAP survey contains 16 items and takes approximately an hour to complete. As shown in Appendix G, I scored participants' responses using the rubric provided by the survey developers to describe the participants' beliefs about the nature of mathematics, teaching mathematics, and learning mathematics (Philipp et al., 2007).

Data Analysis

All interviews were fully transcribed for analysis, and all surveys and field notes from classroom observations were typed for analysis. These documents were loaded in to HyperRESEARCH (Hesse-Biber, 1993) for ease of coding. Then I used three analysis techniques. First, I categorized the participants' beliefs about the nature of mathematics, learning mathematics, and teaching mathematics using Ernest's (1989) framework. I coded data related to beliefs about the nature of mathematics, teaching mathematics, and learning mathematics for each participant. Then I looked at all data coded for a particular element (such as beliefs about mathematics) and determined which category from Ernest's (1989) framework best fit the participant's data. See Figure 11 for an example.

Second, I used the *Initial Model of Factors Affecting Belief Change* to categorize possible factors affecting each participant. I coded my resulting data with the four categories: personal experiences, school experiences, teacher education experiences, and teaching experiences. I constructed another code when a part of the data did not fit into one of these four categories. For example, the participants identified a factor relating more to their internal traits such as personal motivation that could not be categorized as an external experience. Thus, I constructed a fifth category of factors called *personality traits* to accommodate these factors identified by the participants.

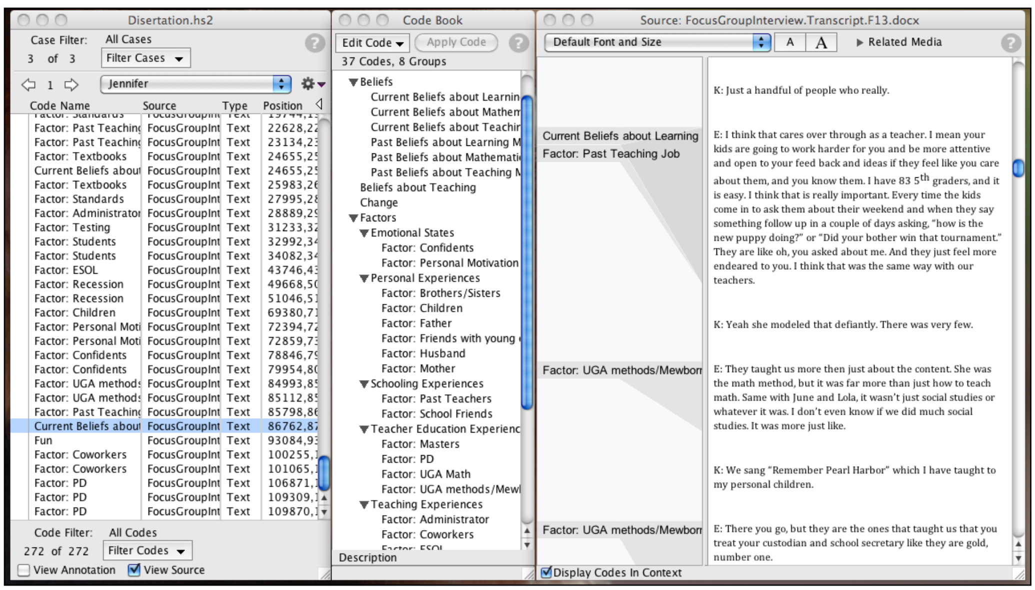


Figure 11. Example of HyperRESEARCH coding.

Third, I looked for links between the factors and the beliefs of the participants. I analyzed the data for instances in which a participant identified a factor as a reason for a belief or belief change. For instance, Laura said having a child of her own enrolled in the same grade she was teaching influenced her beliefs about learning mathematics. I collected all instances of such links across all four participants and created the relationship map.

Once I determined possible beliefs, factors, and links, I wrote a 5-10 page summary of each participant's beliefs, factors affecting her beliefs, and links between factors and beliefs. I asked her to read the summary and indicate whether it reflected her views. The participants generally said the summaries were an accurate reflection of their views. As a result of this member checking I only changed one participant's word choices from her interviews at her request.

Limitations

The study was limited by the number of participants and the kinds of data collected on the participants. First, out of the 14 initial participants in the original study of beliefs, only three teachers were selected for this study. The three teachers were contacted by Dr. Mathis initially to determine if they would be interested in participating, so they were aware of their former methods instructors' involvement in the investigation, which may have influenced their responses to my data collection.

The data were limited to the factors the participants were aware of influencing their beliefs and teaching practices and were able to report to me. Richardson (1996) noted that we are not aware of all factors that affect us; thus we might not even be aware of what influences our beliefs. I used multiple methods of data collection as described above to address these concerns, but it is still likely that there were other factors that influenced the teachers that I was not able to capture in this study.

CHAPTER 4

LAURA

In the following three chapters, I provide a description of each participant's teaching practice and beliefs about the nature of mathematics, teaching mathematics, and learning mathematics from her junior year in the teacher education program through her second year of teaching into her 10th year of teaching. I also present factors that contributed to the stability or change of the individual's beliefs.

Since graduating from college Laura taught in the same district in two different schools. She taught at an elementary school for 4 years in fourth grade, and she taught at a primary school for 6 years, 5 of which were in first grade and one of which was in kindergarten. During that period, she earned her master's degree in Early Childhood Education, was married, and had two children. Spangler et al. (2012) found that of all the participants in the initial study, Laura experienced the largest belief change between her preservice teacher education program and her second year of teaching. I found that Laura's beliefs were more stable across the next eight years although she did experience some slight changes during that time. Laura identified her teacher education program as having the largest influence on her beliefs over time, and she attributed her continued belief change through her 10 years of teaching to the program and her methods instructor. Table 4 provides an overview of Laura's beliefs over the span of both studies.

Laura's Beliefs about the Nature of Mathematics

When Laura started her teacher education program she viewed mathematics as a set of rules to be memorized because of her previous school experiences. The school district in which she was educated adopted Saxon (Hake & Saxon, 2004), a textbook series using a scripted spiral curriculum that emphasizes using procedures to understand mathematics. She explained:

> I was not a student who would try another strategy. I was a student who would learn the first strategy that you taught and I would memorize that strategy. I would understand that strategy, but I would not be interested in hearing any others. As a teacher, that was something I really had to work on. (inter#1)[1]

Spangler et al. (2012) characterized Laura as holding an Instrumentalist view of mathematics in her junior year of her teacher education program because of her belief that mathematics was a set of rules and procedures that must be followed.

Table 4

Laura's Beliefs Over Time

	Stage	Laura
Belief about the Nature of Mathematics	Initial	Instrumentalist
	Second Year	Platonist
	10th Year	Problem Solving
Belief about Teaching Mathematics	Initial	Instructor
	Second Year	Facilitator
	10th Year	Facilitator
Belief about Learning Mathematics	Initial	Passive
	Second Year	Active
	10th Year	Active

Through her teacher education program and her experiences teaching her own students, she “worked on” her views because, as she stated, “I like a set of rules, but I think it’s probably not as set as I previously thought” (inter#2). She explained that from her mathematics content courses she learned how mathematics was developed, and from working with students she realized that mathematics was more than rules. However, she still believed mathematics had a set

[1] (inter #1) represents that the passage originated from the participant’s first interview in this study.

structure. She explained that learning mathematics was like building a house because it had fundamental parts that must be constructed. Students need to “keep building from just learning what a number is, all the way up to algebra and trig and calculus” (inter#3, Study 1)[2]. Therefore after two years of teaching, Laura displayed a Platonist view of mathematics.

After 10 years of teaching, Laura held a problem solving view of mathematics because she saw it not as a fixed body of knowledge but as a continually expanding field of inquiry. She expressed her view of mathematics by stating:

> Conceptually, there is probably not an end, and I think that with all the new developments in technology and things like that, there are a lot of places we never thought math was going to go. (inter#1)

Laura saw how new mathematics was continually created through the development of technology, and she wanted her students to be able to explore mathematics in their own unique ways so they too could construct their own mathematical understanding.

Laura’s Beliefs about Teaching Mathematics

Spangler et al. (2012) categorized Laura’s initial beliefs about teaching mathematics as matching Ernest’s instructor category because she emphasized the need to receive “correct answers” from her students. For instance, in viewing multiple student solutions to a multi-digit subtraction problem in the IMAP survey, she said, “I wouldn't ask Henry to share at this point because his answer isn't correct” (IMAP, Study 1)[3]. Stipek et al. (2001) argued that teachers who have traditional beliefs think that correct answers, good grades, and speed are important in their

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[2] (inter#3, Study 1) represents that the passage originated from the participant’s third interview in the Learning to Teach Elementary Mathematics study.

[3] (IMAP, Study 1) represents that the passage originated from the participant’s Integrating Mathematics and Pedagogy (IMAP) Belief Survey in the Learning to Teach Elementary Mathematics study.

classrooms. Laura believed in giving students procedures to solve problems because, “children may find it quicker to use” (IMAP, Study 1); thus in her junior year of college she was characterized as holding an instructor orientation toward teaching.

When she first started teaching, Laura was an instructor in the classroom, but her beliefs changed significantly across the first two years of teaching. Reflecting back on her early years of teaching, she explained that she would, “sit at that podium. And I would speak the truth of math, and then they were like a little congregation” (inter#2). She knew, however, that this was not the best way to teach, “but I was too scared to change it, and too young to buck the system, and I just felt like I was barely keeping up with the lunch count” (inter#2). Her views on teaching and her teaching practices have changed significantly since that time. Within her first two years of teaching, Laura demonstrated that she believed that presenting students with a variety of ways to solve a problem would help them understand mathematical concepts. She stated, “If they don’t understand it one way, approach it from a different angle. Keep coming at it from all sides until they get it” (inter#4, Study 1). She explained that she learned to focus on student thinking from her methods instructor. Spangler et al. (2012) classified her beliefs about teaching mathematics as progressing to a facilitator orientation by the end of her second year of teaching.

After 10 years of teaching, Laura still believed in being a facilitator in the classroom. With time came self-reflection and awareness. In her interview, she was able to describe her past teaching practices from which I inferred her beliefs about teaching. She stated:

> At the beginning of my career, I was much more focused on standing up in the front and telling you the truth and you practicing it. And now I try to be more like ok let me introduce it, let you go out and try it, and then we will come back and see what you think about it. (inter#2)

Her teaching practice changed because her beliefs about teaching changed. Initially she believed in telling students the concepts. After reflecting on her beliefs, Laura came to believe that students needed to experience “struggle time” (Focus Group)[4]. For students to understand the concepts, she constructed tasks that allowed the students to struggle with the mathematics first to help them understand in a conceptual manner. She stated, “the first time that they get ahold of a concept I like to just kind of throw it out there and let them try it a little bit and see what happens” (inter#2). I observed her students in “struggle time” during her lesson on fact families. She had her students work with a partner to construct valid addition and subtraction equations with the numbers six, four, and two. After talking with their neighbors, students shared their findings and discussed how they knew they constructed the full set of equations. From this discussion, Laura identified the set of equations as a fact family. As she demonstrated in this mini lesson, Laura believed in facilitating students’ learning after 10 years of teaching.

Laura’s Beliefs about Learning Mathematics

In the Learning to Teach Elementary Mathematics study, Laura initially showed little evidence of believing that students should be actively engaged with mathematical ideas. As a learner, Laura earned mathematical knowledge passively. Laura explained that she learned mathematics as a student through memorization. This experience led to her having an initial belief about learning mathematics as a passive activity (Spangler et al., 2012).

Despite her instrumentalist view of mathematics and her passive learning experience, as a teacher Laura constructed a more robust view of learning mathematics. From experiences in her teacher education program, Laura learned that memorization was not the only way of learning

[4] (Focus Group) represents that the passage originated from the participant’s focus group interview.

mathematics. She explained, “So I really tried hard to learn new ways to look at things and how to actually explain things, because some kids are going to actually want to know why. And I've had the experience where they do want to know why” (inter#5, Study 1). In her second year of teaching, Laura showed how she implemented activities in her classroom that allowed for active engagement in mathematics. She personally bought base 10 blocks for her students to investigate mathematical ideas. Laura stated, “I did buy them and did use them because my kids were not learning the way Saxon said magically should be happening” (Focus Group). When asked about her mathematical classroom in her second year of teaching, she explained, “You're not going to see me up there lecturing. I want a lot of hands-on, a lot of experimenting kind of things, and let them figure [out the problem] because that makes it so much more meaningful” (inter#5, Study 1). As she explained, in her second year of teaching she believed that students needed to actively construct knowledge.

After 10 years of teaching, Laura still believed learning mathematics was an active process. When asked if she would describe learning like watching a movie, she stated, “That is so passive. It would definitely be one of the more active verbs not just watching something” (inter#1). She believed mathematics instruction should be hands-on because, “I think that is what they need at this age” (inter#1). In her class, she consistently provided manipulatives for students to touch and use to construct their understanding. For example, the Rekenrek (see Figure 12) was a manipulative the students used in her mathematics centers to help them construct number sense. The students were given cards that contained the problem and given the Rekenrek to help them solve the addition and subtraction problems.

Figure 12. Rekenrek (Blanke, 2008).

Laura believed in students actively participating in learning mathematics and rejected the use of just worksheets without any manipulatives. Parents would even ask her why their students did not come home with worksheets of mathematics problems; she explained:

> Parents would say, “In so-and-so’s class, they bring home worksheet pages every day, and we never see the math our kids are doing.” I’m like, “It is really much better, I promise.” It [the mathematics task in class] actually has pattern blocks instead of a picture of a pattern block. (inter#1)

Therefore after 10 years of teaching, Laura believed that students learn mathematics through active construction of knowledge.

Laura’s Teaching Practice

Laura’s teaching practice after 10 years of teaching was heavily influenced by a restrictive curriculum that was implemented that year. During the Focus Group Interview, Laura explained, “We didn’t do a curriculum for two years. That is what I told her [the researcher]. She should have come last year. We were making up everything, and it was amazing” (Focus Group). Because of these restrictions, Laura’s teaching practice during her 10th year of teaching was consistent with Ernest’s (1989) categorization of an explainer.

Using the MQI I rated the three lessons that I observed Laura teach as a 2 on overall lesson quality and a 3 on overall Mathematical Knowledge for Teaching as shown in Table 5, which means she showed mid-level quality of instruction and demonstrated high levels of Mathematical Knowledge for Teaching.

Table 5

Laura's MQI Scores Across the Three Lessons

Overall Scores	Mean	Median	Standard Deviation
Richness of the Mathematics	2.28	2	0.678
Working with Students and Mathematics	2.16	2	0.688
Errors and Imprecision	1	1	0
Student Participation in Meaning-Making and Reasoning	2.4	3	0.816
Lesson Quality	2	2	0
Mathematical Knowledge for Teaching	3	3	0

From my observations, Laura began each lesson with an activity focusing on students' construction of number sense. For example, she had the students guess the missing addend in the game called "I have. You need." She began the activity by saying:

> Our target number is 8. Everybody make 8 and study it. Look at your fingers, and think about different combinations to make 8. Think about all the different ways to make 8. Ok, are you ready? I have (she puts up 3 fingers). You need? (obs#2)[5]

The students were asked to explain their thinking about how they found the solutions. When differing answers were given, she had the students explain their thought processes. Next, Laura gave the students a mini-lesson on what to do at a center. Laura explained both how the center

[5] (obs#2) represents that the passage originated from the participant's second classroom observation in this study.

would operate and the mathematics the students would need to use. Laura then divided her students into groups to implement that center or other centers, which were introduced in previous classes. While the students were working in their centers, Laura circulated to clarify students' questions about the activities, and she occasionally pulled a student aside to give him or her one-on-one assistance with a mathematical procedure.

Because the centers were student-directed, the students were given many opportunities to participate in meaning-making as shown in Table 5. However, the overall richness of the activities and mathematics implemented were surface level without a focus on deeper understanding of the mathematical concepts. For example, the majority of each lesson focused on teaching the students how to procedurally complete the center. In one observation, thirty minutes of the class period were devoted to having each student come up to the projector to demonstrate they could color in pennies on a hundred board. After each student rolled their dice and colored in the corresponding pennies on the projector, Laura would explain the value the board currently showed. In the lessons observed, much of the mathematics was explained to the students to allow them to understand the procedure.

I categorized Laura's teaching practice as fitting in Ernest's (1998) explainer category. Laura's teaching practice differed from her beliefs about teaching mathematics because of the restrictions placed on her teaching. Laura said her administrators restricted her teaching practice because she was required to implement a designated lesson plan from an adopted textbook series. She commented that such things as the placement of the students' desks to the alignment of her calendar were also controlled by the textbook series.

Factors Influencing Laura's Beliefs and Teaching Practice

Laura experienced the greatest change in her beliefs between the end of her preservice teacher education program and her second year of teaching. Her beliefs became more stable after she began teaching, and with time she became more self-aware of her past beliefs and why she held them. Laura's belief about the nature of mathematics was the only belief to change in the eight years because she was already in Ernest's highest categorization in both teaching mathematics and learning mathematics. In the following section, I describe the factors Laura said influenced these beliefs or her teaching practices over time.

Personal Experience

Parents. Laura's beliefs about the nature of mathematics were constructed through her relationship with her parents. Laura came from a family that valued education, and especially mathematics, in their home. While she was growing up, Laura's father went back to school for his electrician's license. When she was doing her homework, he would do his homework with her, and when she had questions about mathematics, he was there to support her.

Laura constructed her understanding of mathematics at an early age while working with her father. He loved working with his hands from carpentry projects to plumbing work, and he taught these skills to Laura. She explained:

> He modeled for me a lot that math is something we use all the time, and math is an every day thing, and it is important to be neat. It is important to be precise. It is important to take careful measurements. (inter#2)

Because her father had a strong understanding of mathematics and its practical applications, Laura learned to view mathematics as applicable to the real world.

Husband. Laura's husband's views of mathematics greatly differed from her views. Laura talked to her husband about what she did with her students in class, which helped her reflect on her own teaching practice by explaining these views to others. When discussing our interview, Laura reported that her husband told her, "If you are the teacher, you should stand up there in the front. You know you should take your podium back to work" (inter#2). Laura did not agree with his assessment of the teacher's role and explained to him her own point of view, helping her reflect on her teaching practice.

Her husband provided a practical view of the nature of mathematics from a banker's perspective. She stated, "My husband is a banker, and people cross the edge all the time. I think when I taught fourth grade I really tried to teach this to them" (inter#2). She implemented a currency system in her classroom to teach students the value of knowing practical applications of mathematics as well as the consequences of crossing the edge by going over financial limits. Because her husband was a banker, she was exposed to this way of thinking daily, which led her to implement banking practices in her classroom.

Children. Laura had two children who taught her many lessons about teaching mathematics and learning mathematics. She learned from her children that mathematics learning needed both practice and time. She found after working with her own children that students need to be developmentally ready for certain concepts to be comprehended. Laura tried to teach her son his colors before he was developmentally ready, and she found:

> I think that experiences like that with [my son] have helped me to see that it does not matter how many things I pick up that are awesome and amazing. And how bad I want him to do it, but if he is not ready to do it, I can't make him be ready. (inter#2)

Laura found the same thing with other mathematics skills such as addition and subtraction. Some students need manipulatives longer when solving addition and subtraction problems because they are not developmentally and conceptually ready. Because of her experiences with her son, she took time into consideration as another necessary part of learning mathematics.

Laura learned when to implement specific teaching practices from her daughter. Laura's daughter influenced her teaching because she valued her daughter's opinions on the lessons she taught as well as the homework she sent home. Laura explained,

> It has been good for me to kind of see it from her perspective, and I like to talk to her about it every night just to see what she thinks and kind of get her feedback from it. Because I know she is very bright and if something is boring or not good she will tell me, and it is nice for me to know (inter#2).

Laura received feedback from her daughter that influenced future lessons and homework assignments.

Laura thought that she would have picked up on many of the best practices of teaching mathematics, such as letting students talk more and letting them do partner work without having children. However, she explained:

> But I think some things probably not, and just understanding what kids think, and the way they think. It is just something about living with a kid that gives you kind of an intrinsic understanding of some of the craziness that they think, like the connections that they make that you would never assume that they would make. (inter#2)

By living with children, she constructed a new understanding of how students learn and how to teach.

Schooling Experiences

Past teachers and textbooks. Laura's K-12 education experiences were heavily tied to the curriculum that was taught in her district. During her sixth grade year, her school district adopted Saxon, which was a scripted spiral curriculum that restricted teachers to teaching specific lessons on each day. She remembered loving mathematics in elementary school; yet when she went into middle school, she stated:

> I thought all my teachers, my math teachers especially, were terrible, and I thought they were unresponsive. I thought they were reading from a script, and they were cold. They didn't care if people had questions. Now that I have taught, I don't think they had a lot of choice because when I was in sixth grade is when Saxon was adopted. (inter#2)

Laura's beliefs about school mathematics were shaped by this restrictive curriculum. As a student, she was asked to give answers to mathematics questions in one specific way. The Saxon curriculum provided a spiral curriculum that she described as reinforcing memorization of facts more than conceptual learning. Because this was her experience with school mathematics, Laura began her teacher education program with beliefs about the nature of mathematics, teaching mathematics, and learning mathematics that were influenced by this curriculum.

Teacher Education Experience

Mathematics content courses. Laura's mathematics content courses during her undergraduate education helped to change her beliefs about the nature of mathematics. She identified these courses as "really helping" her to understand the mathematics, "so that when I did have to think of another strategy, at least I knew what I was talking about" (inter#2). She learned that she needed mental flexibility in order to understand mathematics, and mathematics was more than a set of rules that she was taught during her K-12 schooling experience. Laura said, “I don’t think I would have had that mental flexibility if I had not really understood what I was talking about. I don’t know if I would have without those courses, as much as I hated them at the time” (inter#2). Therefore, this experience influenced her beliefs about the nature of mathematics.

Mathematics methods courses. When asked what was the single most influential factor on her beliefs, Laura stated it was the mathematics methods courses she took during her undergraduate experience because, “[The university] pushed me. Dr. Mathis pushed me” (inter#1). This push was to learn how to conceptually teach mathematics and to learn how students come to understand the subject. Because Laura had a “traditional” experience as a student, this was a difficult lesson to learn. She explained when she started her teacher education program:

> I liked traditional algorithms. I didn’t really care why I used them. I just knew I could get the right answer if I followed these steps and memorized them perfectly. So it was very eye-opening to have to focus on doing things a little bit differently, and obviously when you start teaching it, it is huge because you don’t get the Carlos’ [a student from the IMAP survey who automatically understood the concepts] come through quite as often. (Focus Group)

She explained that Dr. Mathis “opened her eyes” to a new way of understanding mathematics, thus changing her beliefs about the nature of mathematics. The methods course taught her about different ways of solving problems, but changing beliefs was a slow process. Laura had to first reflect on these beliefs to change how she viewed mathematics and to accept the practices taught in her methods courses as her own.

Teaching Experience

Textbooks. When Laura began teaching, her teaching practice was heavily influenced by the restrictive nature of the curriculum taught at her school. She had to teach from the same scripted spiral curriculum from which she learned during her 6^{th} -12^{th} grade schooling experience. She explained:

> It was just so one size fits all, and there was no differentiation. There was nothing hands-on. We read through those three pages. We worked through these three samples and then we started the lesson. You finished the lesson at home and I checked it the next day. I have no opportunity to give feedback because we have to go to the next lesson. So it just goes home in your folder, and I hope that you look at it, but you probably don't. So you continue to miss the same problems over and over and over. I will try to catch you when I can, but the spiral continues, and I must keep going. (inter#1)

Laura did not like this curriculum, but "I felt at 22 that I couldn't say, 'Oh I am going to take like a week off and just work on this'" (inter#2). The school did change the curriculum after a few years, but during the year she was investigated for this study, the school district again chose a curriculum that was to be implemented the same way in every classroom each day. She explained, "I do feel like it is Saxon all over again" (inter#1), but she felt, "like it is better than Saxon, and I feel like it has a lot of best practices embedded in it" (inter#1). Thus, Laura's teaching practices were influenced by the curriculum adopted by her school.

Administrators. Laura's administrators had a strong influence on her teaching practice. The math coach and a team of teachers chose the new mathematics curriculum the previous year, and it was the principal's decision to have every teacher teach the same lesson on the same day. Together the math coach and the principal made this decision because, "I think what the problem was that the majority of teachers picked the things that were easiest and not the things that were best, so a lot of people were doing that workbook everyday" (inter#1). To counter these teachers' moves, the administration pushed every teacher to implement the new curriculum as the textbook company stated without any deviations.

Laura rarely used workbooks in her class, and she taught the way she believed best met her students' needs. The administrators' restricting actions did not change how Laura viewed teaching mathematics, and she even admitted that she preferred teaching to her students' needs rather than to the set pace. Yet, she had to follow the set curriculum during the semester I observed her because they advised, "to really follow it as it is laid out with fidelity so in the end of the year we can say 'This is what worked and this is what didn't'" (inter#2).

Coworkers. Coworkers influenced Laura in many different ways. Her experiences with other teachers ranged from supporting to hindering, which had multiple effects on her teaching practice. Some coworkers served as a resource to help her reflect on her teaching practices.

Laura worked with a group of first grade teachers in a planning team. Laura took advice from these teachers in her planning team because they all had similar teaching styles and believed in many of the same teaching practices that Laura viewed as important to helping students learn.

Other coworkers served as a deterrent to implementing the teaching practices Laura viewed as most effective for her students. For example, it was her previous math coach who decided to implement the restrictive curriculum, which clearly restrained Laura's teaching. When asked if she would implement activities different from ones specified by her textbook series, she stated:

> No one would probably say anything to me in terms of the coach and my principal. But I don't want to do that because that is going to be hard in terms of my coworkers. It creates a whole new problem. They would say, "Why does Laura get to break the rules and everyone else has to follow them?" (inter#2)

Laura had to consider the consequences of her actions not only on her students but also on her fellow teachers. Thus, her coworkers played multiple roles in how she implemented different teaching practices in her classroom.

Students. Laura's students influenced her teaching practice as well. Laura said that her beliefs about the nature of mathematics, teaching mathematics, and learning mathematics were influenced by her methods courses during her undergraduate program, but she said that it was working with her students that convinced her that what was taught during those courses were best practices. She explained:

> I mean I remember sitting in there [methods class] saying, "I am not going to do that. I am going to do exactly the way that I learned it because it is awesome and I am brilliant. This is fine." And then, she [her methods instructor] was like, "You are really going to have to have some flexibility with that." I'm thinking, "Sure I am. Whatever dude." Then you get out there, and you start working with kids and you are like, "Wow, there was a substantial number of kids who really don't get that, but this other way they do." I just felt like that was the right thing to do for those students. (inter#2)

The right thing to do was to change her teaching practices. Laura reflected on what she learned in her methods courses and took into consideration what she saw from her students while teaching.

Recession. Laura identified the recession as an influencing factor on how she taught her students mathematics. Laura taught in the same district in which she grew up, which gave her a unique perspective on how the community changed over the years. In the early 2000's, there was a big boom in the economy. The building she taught in originally held kindergarten through eighth grade; at the time of my study it only accommodated kindergarten through second grade. In 2003, she started working for the district, which at the time continually hired new teachers and had few students qualifying for free or reduced price lunch. However, since the recession started in 2008, the school and community had undergone a change. Laura explained, "Now we are 58% free and reduced lunch," and, "a lot of kids don't go to school with the basic needs met" (Focus Group). Because of these changes brought about by the recession, Laura felt that she had to assess the students' emotional and physical states as well as assess their learning. This changed Laura's teaching practice because if a student needed to sleep because he did not feel comfortable sleeping at home, then she accommodated his needs. Laura stated that she no longer could depend on parental involvement in her class because parents had other more pressing concerns. Laura changed her homework policy to require only one 15 minute assignment that did not require parental assistance to be completed a week, and she implemented a center where the students would come to her to receive one-on-one assistance. Thus, Laura's teaching practices were influenced by economic situations in her community.

Testing. Laura began teaching early in the implementation of No Child Left Behind and its associated testing program, which required that a criterion-referenced test be given to each student in grades 1-8 annually. Testing influenced Laura's teaching practice only by setting a date for accomplishing the standards. She explained, "I would say the way it influenced my math teaching was you really had to be sure that they were going to be able to work the problems that they were going to be shown on that test in the time constraints" (inter#2). Her first grade students no longer took standardized tests because the state eliminated testing in first and second grades due to budget constraints, but she felt the tests helped her determine whether she was accomplishing her goals as a teacher by having an objective reference point. Laura enjoyed having an external measure to determine if what she was doing was successful by the district's standards.

Standards. As noted in Chapter 3, during Laura's teaching career the state of Georgia transitioned from a set of standards that were not "anywhere near the level of depth necessary for real learning to take place" to a set of standards that "identified the skills needed to use the knowledge and skills to problem-solve, reason, communicate, and make connections with other information" to the Common Core State Standards (Georgia Department of Education, 2013, p. 1). Laura said the standards didn't really affect her beliefs about teaching (inter#2). The standards served to help define what she should teach in her class rather than how to teach. Laura thought, "That [CCGPS] was super helpful for me because I think I was over-shooting the mark really bad on what my definition of knowing something was" (inter#1). She also liked that CCGPS showed the progression over time of how students were to come to understand the concepts, thus influencing her teaching practice.

Past teaching. Laura taught in three different grade levels, and she learned many pedagogical practices from her transition between first and fourth grades influencing her teaching practice. For example, she explained:

> Then I think moving from fourth to first really was a shock, but it really did help me. For instance, the water cycle, some teachers in this grade who have never taught anything but first grade get so upset if their kids do not understand the water cycle. They are like, "they are just not getting condensation." I'm like, "Let me promise you that they will

> hear that again." I taught the whole water cycle in the fourth grade, and they got it much better then. (inter#2)

Laura believed it was the same with mathematics. Her students had multiple opportunities to learn the concepts. By having that knowledge of the standards for a higher grade level, Laura was able to plant seeds of knowledge, such as numbers below zero, with her students that would grow later in their schooling.

Personality Traits

Confidence. For Laura, confidence was a big influencing factor on her teaching practices. She explained:

> I taught the first year or two very much exactly how they [the district] told me and then I am like, "I am going to do my own thing and see what happens." And it was much better, and I kind of got the go-ahead to do what I wanted, but if data didn't support what I was doing then I was going to be in trouble. I had to make sure if I was going to go down that road than I was going to be successful. (inter#1)

As a first-year teacher, she did not have the confidence to go out on her own to do something different, but she grew into a confident teacher who was able to act out what she believed to be best for her students. With a better understanding of what to teach and how to teach it effectively for her students came confidence.

Personal motivation. Laura was very motivated to become the best teacher possible, which affected her teaching practice. Laura's motivation led her to reflect on what was taught in her methods and content courses during her undergraduate teacher preparation program. After she started teaching, Laura's motivation led her to work with other successful teachers. Laura's motivation led her to investigate how her students and children understood mathematics. This motivation came from a lifetime of striving to be the best. She even called herself a perfectionist, and she demonstrated this by how hard she worked for her students and as a student. She joked that she refused her parents' offer to give her 500 dollars to make a B in college to relieve the pressure of making straight A's. Consequently, Laura graduated her undergraduate program with a 4.0 average.

Laura had been employed since she was 14. She explained, "I don't think I could be a stay at home mom if I wanted to," because she liked to work. She was raised to stand on her own two feet and believed that "you are always responsible for yourself" (Focus Group). Therefore, this responsibility of being the best teacher possible influenced her to try new teaching practices, seek professional development to help her learn more about teaching, and reflect on what best met the needs of her students.

CHAPTER 5

JAYNE

Jayne entered the teacher education program displaying the highest level of beliefs in all three of Ernest’s categories (nature of mathematics, teaching mathematics, and learning mathematics) (Spangler et al., 2012). From her preservice experience into her second year of teaching, Jayne progressed in her beliefs, despite the fact that little improvement was available to be made. She experienced little to no change in her beliefs over the next 8 years of experience as shown in Table 6 because she reached the highest level in Ernest’s classification after her second year of teaching.

Table 6

Jayne's Beliefs Over Time

	Stage	Jayne
Belief about the Nature of Mathematics	Initial	Platonist
	Second Year	Problem Solving
	10th Year	Problem Solving
Belief about Teaching Mathematics	Initial	Explainer
	Second Year	Facilitator
	10th Year	Explainer / Facilitator
Belief about Learning Mathematics	Initial	Active
	Second Year	Active
	10th Year	Active

Since leaving her teacher education program, Jayne taught first grade in the same school for 10 years, experiencing change in both her community and students. During that time, she was married, had two children, and earned a master’s degree in Early Childhood Reading and Literacy. These life-changing events reinforced her previous beliefs about the nature of mathematics, teaching mathematics, and learning mathematics. In this section, I characterize Jayne's beliefs and identify the factors influencing those beliefs over time.

Jayne's Beliefs about the Nature of Mathematics

When entering her teacher education program, Jayne showed little evidence in her IMAP data of believing in mathematics as a web of interrelated concepts and procedures. However, Jayne did not see mathematics as set of rules but rather a structure students needed to learn to maneuver through. Jayne viewed mathematics as an interconnected jigsaw puzzle:

> Because it's like you learn, you see bits and pieces of things, and you know they're all going to fit together, but it takes time for you to learn them first, like after you learn one plus one is two, you can build from there. (inter#1, Study 1)

Jayne initially held a Platonist view of mathematics (Spangler et al., 2012).

As she began working with students and was introduced to new concepts and structures in her methods courses, Jayne showed evidence in her classroom practice of a problem solver's view. She learned to value multiple solutions to mathematics problems by watching experienced teachers in her methods courses.

In her second year of teaching, she emphasized that there were "different ways to solve problems" (inter#7, Study 1), and she assessed her students' understanding through multiple methods. She did not view mathematical understanding as learning a set procedure; rather she viewed mathematics as problem solving. She explained it was unfair that her students had to take a test where "Some kids might know how to solve the problem, but the way it was worded they couldn't explain. So, that's not a true assessment" (inter#7, Study 1). Thus after two years of teaching, Jayne demonstrated a problem solving view of mathematics.

After 10 years of teaching, Jayne still held a problem solver's view of mathematics. She even again described mathematics as a jigsaw puzzle, but she no longer believed everything must fit together the same way. Jayne explained, "math is like a puzzle" with multiple pathways that students can construct to understand a problem (inter#1). She explained, "I feel like the end result can come out to be the same, but the way we approach it or think about it would be different" (inter#1). She believed teachers should not stifle the creative process. Jayne saw this creativity in her students by observing the "way my children think differently" (inter#1). Jayne designed activities in her class that centered on problem solving. In an observation during her 10th year of teaching, her students were tasked to construct a cube and a rectangular prism using marshmallows and toothpicks. Jayne made this a problem solving lesson by placing her first graders in pairs and having the students manipulate the objects to construct the three-dimensional shapes without explaining the process first. This is one example that illustrates that Jayne had a problem solver's view of mathematics after teaching for 10 years.

Jayne's Beliefs about Teaching Mathematics

Jayne initially believed that it was the mathematics teacher's role to explain concepts to her students. Her IMAP survey data from the Learning to Teach Elementary Mathematics study did not show strong evidence that she believed that students could solve problems in novel ways without being taught how to solve them first. She explained, "[A teacher] should model more than one problem, making sure that each time she explained her steps" (IMAP, Study 1).

Jayne's beliefs changed in this respect during her teacher education program. In her senior year of college, she described her classroom as having " a lot of small group work; you'll see it probably won't be a quiet classroom. It will be kids talking, reasoning, and explaining things" (inter#4, Study 1). Jayne explained, "It's not so much me telling them anything; it's them telling me "(inter#4, Study 1). Jayne progressed from explaining the mathematics to helping students understand concepts through discussions and student-to-student interaction. After she became a teacher, she continued to reinforce this belief in facilitating learning. For example, she was observed in each of her classes asking questions to elicit higher-order thinking. Therefore, after her second year of teaching Jayne adopted a facilitator role as a teacher.

After 10 years of teaching, Jayne viewed teaching mathematics as a combination of modeling and facilitating, and the transition between the two corresponded to when her students were developmentally ready. Jayne stated:

> I don't think I can expect my kids to do something if I haven't modeled the appropriate strategy or given them the appropriate tools to solve the problem. I would never just give my kids a word problem, and never have taught them before like, "Here is a good way of approaching the problem." I feel like the modeling comes first. (inter#1)

The modeling process was needed for both the mathematics as well as the instructions of the activities. The amount of modeling corresponded to the needs of her students. She explained, "I feel like as the year progresses, I kind of start to cut the string, less of me modeling, and more of you reading and trying something first" (inter#1). She demonstrated her belief in facilitating learning in her observation during the lesson using the toothpicks and marshmallow constructions because she did not model how to construct the figure. The students were charged with constructing the mathematical object within their group. In another observation, she modeled how to measure items first as part of her lesson on using non-standard units. After 10 years of teaching, Jayne believed teachers needed to explain and facilitate learning for their students.

Jayne's Beliefs about Learning Mathematics

Jayne's beliefs about student learning stayed constant throughout her mathematics education program and into her second year of teaching. She believed students needed to actively construct knowledge of mathematics to understand the concepts. She initially showed strong evidence that one's knowledge of applying procedures does not necessarily go with understanding concepts and that students learn mathematics concepts before procedures. For example, she explained in one of her methods class assignments that students learn best through use of manipulatives. While she was student teaching, she expressed that she disliked the students' working environment where "there were just a lot of worksheets, a lot of 'open the book to page blah, do these problems'" (inter#2, Study 1). When asked why she disagreed with the learning environment, she explained, "different kids think in different ways," and worksheets only supported one kind of learner (inter#2, Study 1). When she started teaching, she implemented tasks to help her students learn through social teamwork rather than mainly personal activities. Jayne constructed tasks where students worked together, and she maintained that "knowing your kids" was the most important factor in helping students learn (inter#4, Study 1). She believed in letting students construct their own learning rather than sitting in the classroom and accepting the teacher's instruction. During her second year of teaching, she was observed placing students in small groups and allowing them to use manipulatives to construct understanding of the concepts. By having her students reason through the mathematics, she showed how she constantly implemented a belief that students need to actively construct knowledge of mathematics.

Jayne consistently held a belief that students learn mathematics through active participation after 10 years of teaching, which she demonstrated in two ways. She had her students using tools to understand the mathematical concepts in each lesson I observed. For example, in her last observation, the students constructed a unit of measurement from their foot to measure objects around the room. Jayne stated,

> I just feel like them looking at a picture in a book where they have to draw their own beads as opposed to them taking something and actually measuring it themselves, there is no comparison there for me. I just don't feel like it is meaningful to my kids. (inter#2)

By having the students construct a unit of measurement and then practice measuring items, she believed her students were able to develop understanding of measurement.

She believed students actively engaged in the mathematics through discourse. She explained, "I like to hear them talk, and I like for them to talk about what they see and what they are thinking even if it is wrong, because it helps me see where they came from" (inter#1). She had her students participate in mathematical discussions during each one of her math centers to help them "justify what they think" (inter#1). All these ideas stemmed from Jayne's deeply held belief that, "If I don't think it is best for kids, I don't do it" (inter#2). Throughout her preservice teacher education program into her 10th year of teaching, Jayne viewed active engagement in the mathematics as what was best for her students' construction of knowledge.

Jayne's Teaching Practice

Using the MQI I rated two of Jayne's lessons as a 3 for overall lesson quality and the third as a 2 as shown in Table 7, meaning only mid-level quality of instruction was observed. However, Jayne's teaching practices while implementing each of these lessons were consistent with Ernest's categorization of a facilitator of learning.

Jayne's mathematics lessons shared a similar structure. She began the lessons by having her students watch and participate with a YouTube video reviewing either counting facts or the names of 3-D shapes. After the videos, Jayne asked predetermined questions about the previous lessons. Next, she introduced the activity for the day either by reading a book or by demonstrating the task. Afterward, the students were placed in predetermined groups where they implemented the task.

Table 7

Jayne's MQI Scores Across the Three Lessons

Overall Scores	Mean	Median	Standard Deviation
Richness of the Mathematics	2.625	3	0.5
Working with Students and Mathematics	2.438	3	0.727
Errors and Imprecision	1	1	0
Student Participation in Meaning-Making and Reasoning	2.438	3	0.727
Lesson Quality	2.667	3	0.577
Mathematical Knowledge for Teaching	3	3	0

Jayne co-taught during many of her lessons with an early intervention program (EIP) support teacher, which enabled her to work with one of the small groups of students while the support instructor worked with another group. During their interactions, they both asked questions to elicit the students' mathematical thinking. The students participated in high levels of meaning-making and reasoning as shown in Table 7. At the end of the lesson, Jayne brought the students back together to discuss the different tasks and ask students questions to deepen their understanding of the concepts. For example, at the end of one lesson she asked:

1. How can we know if we have a rectangular prism?
2. Do you think this side is exactly the same as the other side? What do you think we could do to check? (obs#2)

Using questioning, Jayne was able to determine the students' understanding of the concepts in the lesson.

For the lesson that was categorized as mid-level quality, Jayne implemented a task that did not support a rich mathematical discussion, yet she was able to use questioning strategies to help students understand the mathematical concepts. Because she helped her students come to know mathematical concepts through questioning in each of the lessons I observed, I categorized her teaching practice as matching Ernest's description of a facilitator of learning.

Factors Influencing Jayne's Beliefs and Teaching Practice

Jayne experienced little change in her beliefs during her teacher education program, and they stayed constant after 10 years of teaching. She attributed this to her overarching beliefs not changing. In this section, I report on the events and individuals that Jayne identified as influencing the stability of her beliefs across time.

Personal Experience

Parents. Jayne's beliefs about the nature of mathematics were developed from her relationship with mathematics and her parents. Jayne grew up in a family where education was very important, and her parents were actively involved in her school life. She said:

> My mom was a room mom. When I came home they checked my folders, and whenever I had homework, obviously they did it with me when I was younger, but the older I got I would do it and they would check it at night. I remember being woken up early in the morning for them to go over the ones that I had missed and re-teach it to me. (inter#2)

Jayne's mother was very knowledgeable in mathematics and taught Jayne to view mathematics as a way to solve real-life problems. For example, when Jayne was young they would go to the grocery store and calculate the price of their groceries with coupons to the dollar. She stated, "I remember her making it a game. So for me math was applicable to my life, and it was fun" (inter#2). Making mathematics fun and useful became a strong belief for Jayne, and she attributed this to her parents by saying, "I don't know if I liked it because I was good at it or because I thought numbers were fun, but I do think a driving force was the fact that it was important to my parents" (inter#2). Because math was important to her parents, it became important to her, influencing how she saw the nature of mathematics.

Husband. Jayne's husband was very mathematically minded, which reinforced Jayne's beliefs about the nature of mathematics. He worked in construction before becoming a firefighter, and Jayne valued his mathematical knowledge. She stated, "There is so much math and equations that go into knowing how much pressure you use, and how not to run out of water" (inter#2). However, their main discussions about mathematics were either centered on their sons' mathematics education or centered on games. Jayne was able to reflect on her beliefs by discussing these ideas with her husband. From discussions of mathematical activities they did that day to what apps should they place on their iPad, they discussed practices that would best ensure that their sons would build a solid conceptual understanding of numbers.

Just like her parents, her husband valued mathematical games and puzzles, thus reinforcing her belief that mathematics was like a puzzle. She explained, "We actually both love puzzles. Anything for your brain, so we are always buying little unknown number books and puzzle books" (inter#2). Thus, Jayne's husband reinforced her beliefs about the nature of mathematics.

Children. Jayne's sons influenced her teaching practice. She saw her two boys learn their shapes and colors, and she noticed how naturally curious they were about the world. From the interaction with her sons, Jayne learned how she could incorporate mathematics into other areas. She explained, "With him [one of her sons] I am realizing, you can pull math into everything and anything. It does not have to be math time to pull math into things" (inter#2). She described how her son could learn math from everyday experiences, from identifying shapes on his body to practicing counting by playing firefighter in the backyard. She learned, "What's applicable to their world means more to them and they retain that" (inter#2). She explained she implemented activities in her class that incorporated real world items and concepts because of her sons' influence. Thus, observing what helped her son learn affected how she taught her students.

Schooling Experiences

Past teachers. Jayne's previous teachers were an initial influencing factor on her beliefs about teaching mathematics and learning mathematics. When she was in school, most of her experiences with mathematics were "traditional," but she never had a negative experience with her mathematics teachers because she always liked mathematics. She explained, "I don't remember teachers teaching me math in a really fun way. I remember it being more procedures, and computation, and memorizing equations. But I liked it" (inter#2). If she didn't understand a concept, she felt comfortable going to her parents for help, but she identified that:

> It wasn't until Dr. Mathis that I was really challenged in my thinking about math. I came from a generation that liked the algorithm. I could do it in my head, but I couldn't necessarily tell you what the regrouping meant or why that worked. That was when my eyes were kind of open to how you should really be teaching children. (inter#2)

Jayne's past teachers influenced her initial beliefs about teaching and learning mathematics. As described earlier, her beliefs as of her 10th year of teaching differ from when she entered her teacher education program, but her previous teachers did serve as a guiding force in how she came to learn and know the subject.

Teacher Education Experience

Mathematics methods courses. When asked about the number one influencing factor on her beliefs, Jayne identified her teacher education program's mathematics methods courses. Dr. Mathis's courses influenced Jayne's beliefs about the nature of mathematics, teaching mathematics, and learning mathematics. Jayne stated, "My experience in college with Dr. Mathis really caused me to think of it less like a subject I like and more as thinking of the life of a child and the thoughts of a child and how math would make sense to them" (inter#1). During these courses, Jayne developed and learned about different teaching styles because the practices aligned with her belief in "doing what is best for my kids" (inter#2). When I asked her what made Dr. Mathis's courses so influential, she explained:

> It was probably one of the only classes that I really truly used. It wasn't like I learn about this, think about this. It was more like "learn about it, get it, you are going to use it," and I do. (inter#1)

Jayne explained that Dr. Mathis really "pushed" them to learn the mathematical content and then gave strategies she could use in her own classroom to teach the content. Jayne identified the learning to be difficult, but she felt that made it more meaningful. Jayne explained, "You know I remember her pushing us to really understand what math meant. What these concepts meant. Until I had Dr. Mathis, I never really had to think about why that number meant that" (inter#1). Jayne's beliefs about mathematics were challenged, which allowed her to reassess what she believed about mathematics teaching and learning to construct her current beliefs.

Professional development. Jayne had one professional development experience that she felt was the most influential to her teaching practice. Her district has a Math Institute where she participated as a student for several years before becoming an instructor. She explained:

> We got to watch a mini lesson, and then we got to work with groups of kids. And so it was a really good way for me to pick up some new strategies and some new activities that I could immediately put into place. (inter#2)

She taught at the Math Institute and developed different lessons to help other teachers. However, she explained, "It didn't necessarily change my math thinking as opposed to giving me things that are easy to incorporate" (inter#2). Her beliefs stayed consistent, but she was always looking for new methods and strategies to help her students succeed, and the professional development experience provided that opportunity.

Teaching Experience

Coworkers. Jayne's coworkers were a resource from whom she learned about mathematics teaching, but again she did not feel that they influenced her beliefs. When she had questions about mathematics, she identified her math coach as being a good resource. She explained, "We [fellow first grade teachers] talk about stuff all the time, and not just in a collaborative meeting. We are talking at lunch" (inter#2). The coworkers provided the support to reflect on her teaching practices.

Jayne's coworkers served as extra assistance by helping her teach the mathematics class. The music teacher worked as the Early Intervention Program instructor at her school, and he helped as an assistant on a regular basis. I observed two lessons he assisted. She explained, "I guess it hasn't necessarily changed my beliefs. I see it has a benefit because for my kids, the numbers are smaller. Instead of me getting one group a day or two groups a day, I can get twice as many because he is in here" (inter#2). Jayne worked to incorporate him into her lessons to create a productive work environment for her students.

Jayne worked with coworkers from various schools on the district's assessment team to create the math assessment for all first grade students. By constructing assessments, she became more aware of the standards and, "It was holding me a little more accountable for what I should be teaching, and made sure the activities in my classroom mirror what they really needed to know" (inter#2). Jayne's coworkers influenced her teaching style more than her teaching beliefs; yet by working with her coworkers, she constructed new practices to help her students learn mathematics.

Standards. Another factor that influenced what Jayne taught was the curriculum standards. As noted in Chapter 3, the introduction and assessment of the standards changed many aspects of what she should teach over the years. When CCGPS was introduced, she explained:

> I feel like the pacing was much faster [than GPS]. I feel like when I first started teaching I was able to spend a ton of time on adding and subtracting when it is just interwoven into the Common Core. I feel like I could pace myself a lot more according to my kids. (inter#1)

However, just because the pacing was different did not mean she taught her students differently. She believed that she must "do what is best for my students," by which she meant, "If my kids don't get it, I'm not moving on because they are not going to get it" (inter#1). So even if the pacing guide said she should go on, she moved at the pace of her students' understanding.

Technology. Technology did not influence Jayne's beliefs about teaching or learning, but it influenced how she implemented teaching and learning in her classroom. She used YouTube videos on her interactive white board to help introduce and review concepts for her students. During her observations, she began each lesson with a counting exercise from YouTube. She had students on computers and iPads during centers to practice different skills. Jayne explained:

> They are interested in it. It keeps their attention and it's fun. It applies to what we are doing. I think it is a great tool, a great resource, and I don't think it will ever replace teachers even though some people think it can. (inter#2)

The technology helped to make the mathematics fun for the students, which directly related back to Jayne's belief that to learn mathematics, students need to be engaged.

Recession. A factor that influenced Jayne's teaching was the 2007-2009 economic recession. Jayne taught at the same school for over 10 years, allowing her a unique insight into the community. Because of the economic situation, she observed parents having less time with their children because they needed to work. The recession hit her community very hard. Jayne explained:

> I really think situations have changed. I feel like parents who might not have had to work are now working one or two jobs. When I first started teaching here, I would say like a majority of my kids in my class came from a two-parent home where they weren't at daycare in the morning or daycare in the afternoon. Their homework was done with someone, and a lot of my kids now, their parents are working one to two jobs. They are working long hours. Their kids are spending more time in daycare. They're getting up early to go to daycare. They are leaving here and going to daycare. It is all parents can do to get their kids fed, bathed, and in bed. I feel like the recession played a big part in it. (inter#3)

As a result of the recession, her school became a Title 1 school because it had a high percentage of students from low-income families. When asked how her teaching changed because of this influence, she stated, “I feel like I don’t take for granted thinking that they already know things” (inter#2). She implemented many activities to assess her students’ understanding of basic concepts, and then she determined where she should begin the lesson from that point. Or, she pulled specific students aside to work on the basics. Because of the recession, Jayne believed, “They are coming in with less background knowledge and needing more from us” (inter#2); thus her teaching was influenced by the national economic situation.

Personality Traits

Confidence. As noted above, Jayne had a strong belief that teachers should only do what is best for their students. Because she had confidence in what she was doing, Jayne was able to implement her beliefs about the nature of mathematics, teaching mathematics, and learning mathematics in her classroom as a beginning teacher. She consistently held the same beliefs and practices since her second year of teaching, and it was directly related to her confidence. When I asked her if she would change her teaching style for an administrator, she responded:

> If I thought it was not what was best for my children, and I was doing what was best for them, then probably not. If they come to me with genuine concerns and there is something I really should be changing, and it makes sense that I should, then, yeah, I am open to discussing things. If there is a better way, that is fine with me, but probably not. (inter#1)

Because she was confident that her teaching was supporting success in her students, she maintained the same teaching practice and beliefs over the years.

Personal motivation. One of the most influential factors on Jayne's belief development was her personal motivation to be the best teacher possible. Jayne's motivation led her to work hard as a student to learn from her mathematics content and methods courses. Jayne's motivation led her to work with other teachers in professional development and collaborative teams.

This motivation was constant throughout her life. She always worked hard in her math courses because she believed it was her "job," and she wanted to do it well. She identified herself as a perfectionist. She explained, "I am always someone that can go with the flow and be flexible, but if I am going to do something it's going to be 100%. I have always been that way" (inter#2). From being a member of the team constructing assessment tasks for all first graders in the district to being an instructor in professional development classes, Jayne put forth 100% of her time and effort to becoming the best teacher possible.

CHAPTER 6

JENNIFER

Compared to Laura and Jayne, Jennifer's belief change was significantly different. Jennifer experienced little influence on her beliefs initially from her pre-service teaching experience. After she started teaching, Jennifer began to reflect on her beliefs and define what she believed to be best practices for her students. Therefore, she experienced the largest change of beliefs while she taught as shown in Table 8.

Over the 10 years, Jennifer experienced various events that shaped her views on the nature of mathematics, teaching mathematics, and learning mathematics. She lived in three different states and taught elementary school in second through fifth grade. She was married, had a child, earned a master's degree in Curriculum and Instruction, earned a specialist in Educational Leadership, experienced job transfers, was divorced, and moved back to her home state. In this section, I describe her current beliefs about the nature of mathematics, teaching mathematics, and learning mathematics, and how her life experiences influenced these beliefs.

Table 8

Jennifer's Beliefs Over Time

	Stage	Jennifer
Belief about the Nature of Mathematics	Initial	Instrumentalist
	Second Year	Instrumentalist
	10th Year	Problem Solving
Belief about Teaching Mathematics	Initial	Explainer
	Second Year	Explainer
	10th Year	Facilitator
Belief about Learning Mathematics	Initial	Passive
	Second Year	Active
	10th Year	Active

Jennifer's Beliefs about the Nature of Mathematics

Jennifer initially held an instrumentalist view of mathematics (Spangler et al., 2012). She believed mathematics to be a set of rules that she must transmit to her students. In her junior year of college, Jennifer explained in her initial interview that she viewed mathematics like a recipe book because, "Recipe books tell you what to do and you pretty much do it. It's kind of how we have to do it [math]" (inter#1, Study 1). During student teaching, she found enjoyment using the Saxon mathematics curriculum because "There's a lot of routines in it" (inter#3, Study 1). Thus, Spangler et al. (2012) characterized Jennifer during her preservice teacher education program as holding an instrumentalist view of mathematics.

Jennifer's view of mathematics did not change after she started teaching. In her second year of teaching, she explained how she taught items by checking them off a list. The fact that she believed she could check off a skill in mathematics showed her belief that mathematics consists of rules still remained. Spangler et al. (2012) reported that Jennifer stayed consistent with her instrumentalist views throughout the initial four-year study.

After 10 years of teaching, Jennifer experienced a drastic change in her beliefs resulting in her holding a problem solver view of mathematics. She saw mathematics as continually changing with her students able to solve problems in "unique and creative ways" (KFABC)[6]. She described her belief by defining what she did not believe, showing her reformed views. She explained, "Cooking with a recipe? Definitely not, because that is like the whole algorithm. You do it this way: step 1, step 2, step 3, step 4. That is not the way that I think of math" (inter#1). She enacted this belief by implementing problem solving activities in each of the classes I observed.

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[6] (KFABC) represents that the passage originated from the participant's Known Factors Affecting Belief Change survey.

For example, in the first lesson observed in her 10th year of teaching, Jennifer had her students find the most cost-efficient way of sodding a field as shown in Figure 13. The students were given this task to explore the mathematics, and Jennifer introduced the activity to her students by saying:

> Think about what you will figure out first, and what you will we figure out second. I didn't give you how I would solve the problem because you might think of it differently than how I would like to do it. If you get really stuck, I will give you some help, but only if you have really tried. What I am asking of you is to have a good attitude, be patient, take some risks, and try some things. (obs#1)

Consequently, the students were able to take risks and use their problem solving skills to solve the problem.

The Grass is Always Greener

The Westend Recreation Center Booster Club is considering replacing the existing grass football field with a new type that is softer that provides better traction. Visiting teams have been complaining about the large number of injuries from inadvertent slips on the slippery sod. Local fans have agreed to volunteer labor and equipment. The Booster Club is concerned only with the cost of the sod for the field. They are looking for the best buy for their money.

Below are price quotes from various local nurseries:

6' x 2' roll \$1.00
6' x 6' roll \$4.00
8' x 3' roll \$2.00
6' x 3' roll \$3.00

The field dimensions are 120ft x 160ft.

Which is the best buy?
How many rolls of sod will be needed?
What will be the total cost of the sod?

Figure 13. Jennifer's task from observation 1 (CCGPS Frameworks Student Edition, 2013, p. 65).

In the third observation she used a comic strip to add context to word problems asking students to solve how far a frog could jump from a ladder. In each lesson, she emphasized to her students that mathematics involved constructing a plan to solve problems, and she celebrated the use of multiple unique strategies in her classroom. She explained to her students “We don’t want everyone in this world to do things in the same way. We want people to do things kind of in their own way and share those things” (inter#1). Jennifer celebrated students’ novel thinking by having them come up to the board to teach other students. By emphasizing problem solving in her classroom, Jennifer demonstrated how she had students create their own understanding.

Jennifer’s Beliefs about Teaching Mathematics

Jennifer held an explainer view of teaching during her junior year of college (Spangler et al., 2012). Jennifer entered her teacher education program believing that mathematics teachers should explain to their students how to solve mathematical problems using manipulatives in structured activities. These ideas stemmed from her belief in the importance of making mathematics fun. Jennifer did not like unstructured activities and stated, “I never felt open to experimenting and figure things out on my own” (IMAP, Study 1). She thought those forms of inquiry would make mathematics less enjoyable and less meaningful. Jennifer’s beliefs about teaching mathematics stayed constant through her second year of teaching (Spangler et al., 2012). Neither her teacher education program nor her first two years in the teaching profession altered her belief that teachers should explain the mathematics for her students.

However, after 10 years of teaching, Jennifer experienced a change of beliefs about teaching mathematics because of different factors in her life. Jennifer explained:

> I guess when I started off teaching I did a lot more modeling and explaining because that was mostly what I had been exposed to. And then through a lot of different professional

> development, I guess I have learned more about viewing myself as a coach rather than a bearer of all knowledge. It made me realize if I just stand up there and explain it, there are a few kids that will learn that way, but the majority of the students will not learn in that way. (inter#2)

Jennifer was able to acknowledge her change and identify that she no longer believed in being the bearer of knowledge. She displayed this belief in the lessons that I observed. For example, during the first observation, she wanted her students to come up with their own ways of solving the problem, so she purposefully did not show them any examples of how to solve the task. She explained, “I am giving them the instruction, but they are the ones that are actually doing the hard work” (inter#1). She viewed teachers as coaches, and she believed that students should do the mathematics. After 10 years of teaching, Jennifer viewed the mathematics teacher’s role as a facilitator of mathematics.

Jennifer’s Beliefs about Learning Mathematics

Jennifer’s initial beliefs about students learning mathematics were based on her own learning during her K-12 schooling experience. Her teachers treated her as a passive recipient of knowledge; thus she believed that was what students needed to do to learn the subject. However, “fun” was a central theme in Jennifer’s beliefs about children learning mathematics. Jennifer’s definition of fun consisted largely of disguising mathematics so students did not notice that they were learning; she seemed to think she needed to shield students from the unpleasantness of learning mathematics. She mentioned, “if you really make math fun and you give them all the tools they need, the manipulatives, and make it fun, put a lot of effort into it, they’ll be more successful” (inter#1, Study 1). For her, the basic addition, subtraction, multiplication, and division facts were tools students could use to solve problems. She explained, “You give them basics, you kind of give them the things to get going and let them work with it and figure it out" (inter#1, Study 1). As this quote suggests, she showed glimpses of moving away from a passive view of learning, but in her classroom practices, she demonstrated a passive view. In her observations, she demonstrated "giving" knowledge to her students by having them replicate her actions rather than constructing their own understanding of the mathematics. For example, Jennifer would direct her students to "Do the worksheet just like we did right before. Just like I did up here" (obs#3, Study 1)[7]. Therefore, her view of students' learning was consistent with Ernest's classification of students being passive recipients of knowledge.

Through her teacher education courses Jennifer came to understand that students need to know why things happen in mathematics, and she started to believe that "someone who is good in mathematics is able to solve the problem correctly as well as explain the steps they took, and why" (inter#5, Study 1). Jennifer equated active learning with using manipulatives, which also aided in her desire to make math fun. From her methods courses she learned about using manipulatives to investigate mathematical concepts, but she filtered this hands-on approach to learning mathematics through her belief that mathematics should be fun. She saw hands-on learning as a way to motivate her students to learn the curriculum. Consequently, she implemented the use of manipulatives in her classroom as much as possible.

During her second year of teaching Jennifer's use of manipulatives in her classroom suggested that her view of learning was that a good mathematics student can explain why. Therefore, Jennifer was moving toward viewing students as active learners who need to interact to learn.

[7] (obs#3, Study 1) represents that the passage originated from the participant's third classroom observation in the Learning to Teach Elementary Mathematics study.

After 10 years of teaching, Jennifer came to see manipulatives as a way for students to develop and demonstrate conceptual understanding, and she defined active learning as engaging with conceptual mathematical ideas. She believed the students needed to actively engage with the mathematics to learn the concepts. Jennifer acknowledged that this belief about active learning initially stemmed from her interest in making mathematics fun. However, now she explained, “I want math to be fun, and I want the kids to enjoy class, but my goal is not to entertain them. My goal is to help them learn” (inter#1). She believed that she could reach this goal of learning by building “a solid foundation, which in my mind is number sense” (inter#1). The foundation was built by first using manipulatives. She explained:

> Because clearly the fifth graders think they don’t need blocks, so rather than trying to convince them that they do need blocks, I would say, “Well, how would you show this to a second grader?” And if they can show me with the blocks how they would show a second grader, I know they get it. If they are struggling to show what they think is basic with blocks, then maybe they have just generalized so much or learned patterns or learned formulas that they don’t actually know the number sense behind it. (inter#1)

Jennifer believed students needed to engage with the manipulatives to build a conceptual understanding of the mathematical concepts rather than memorizing patterns or formulas. Thus, Jennifer believed in actively engaging the students in the mathematics in her classroom.

She described other ways her students engaged with the mathematics, such as mathematical discourse. She explained that her students were able to have “awesome math discussions” (inter#1) based on problems she posed. During each observed lesson, the students were placed in groups to engage with the mathematics through discourse. After 10 years of teaching, I categorized Jennifer as still believing in actively engaging students in mathematics.

Jennifer's Teaching Practice

Using the MQI I rated all three of Jennifer's lessons as a 3, the highest rating as shown in Table 9, for overall lesson quality and overall Mathematical Knowledge for Teaching. From these observations, I categorized her teaching practice as consistent with Ernest's description of a facilitator.

Table 9

Jennifer's MQI Scores Across the Three Lessons

Overall Scores	Mean	Median	Standard Deviation
Richness of the Mathematics	2.429	3	0.69
Working with Students and Mathematics	2.321	2	0.723
Errors and Imprecision	1	1	0
Student Participation in Meaning-Making and Reasoning	2.607	3	0.629
Lesson Quality	3	3	0
Mathematical Knowledge for Teaching	3	3	0

Jennifer followed specific classroom routines in each lesson I observed. While the students entered her room, Jennifer displayed on her interactive white board a problem of the day such as the following:

1. Grayson divided 4,509 by 9 and got 51. Is this answer correct? Explain why or why not. (obs#1)
2. Keith cut 0.5m from a length of rope. Then he cut what was left into four equal pieces. If each of the four pieces was 1.25m long, what was the length of the rope before Keith cut it? (obs#2)

The students were asked to solve these questions using multiple methods, and Jennifer called on her students to give examples of differing ways they thought about these problems.

Jennifer facilitated her students' learning of the mathematics by initially asking pre-planned questions focusing on students recalling information learned from previous lessons. Next, the students were assigned to predetermined groups designed to engage students in tasks that required significant mathematical thinking. Once in the groups, the students discussed the task to construct a solution. The students were highly engaged in meaning-making and reasoning as evident in Table 9. At the end of each lesson, the students were asked to give their strategies for solving the tasks, and Jennifer specifically focused on her students giving multiple strategies. For example, during one of her lessons, Jennifer had students come up to the front of the class to demonstrate the multiple strategies they constructed. Finally, Jennifer facilitated a classroom discussion focusing on the students' justification of the validity of each method.

During these lessons, Jennifer served as a guide to help her students through the tasks. In one of her interviews, she stated that she purposefully did not give her students a specific way of solving problems because she wanted her students to do the mathematical thinking. She wanted her students to work harder than she did on the mathematics. Therefore I categorized her teaching practice after 10 years of teaching as consistent with Ernest's description of a facilitator of learning.

Factors Influencing Jennifer's Beliefs and Teaching Practice

Just like Laura and Jayne, Jennifer's beliefs progressed to Ernest's highest categorization, but Jennifer's belief change occurred later in her career compared to the other participants. Her teacher education program first appeared to have no effect on her beliefs about teaching, but over time she showed evidence of using the practices advocated in that program. In this section I describe the events and individuals that influenced Jennifer's beliefs over time to explain how she came to her beliefs and teaching practices.

Personal Experience

Parents. Jennifer explained that "Math was always a part of my life" (inter#1) because she came from a competitive family that loved puzzles and the practical nature of mathematics. Her family played number association games with license plates and had competitions to calculate grocery prices. Her family reinforced a practical view on the nature of mathematics. Her parents instilled how math was used in the real world to find solutions to everyday problems. Both of her parents owned businesses, and Jennifer became the bookkeeper for her mother's business as a part-time job in college. She explained:

> To this day, I balance my checkbook to the penny. I make sure they match my account and my statements, because that is how I was raised. My mom put that importance of math into us. From a business perspective, everywhere we went, math was with us everywhere. (inter#2)

Her experiences with her family caused her to see mathematics everywhere and influenced the construction of her beliefs about the nature of mathematics.

Children. Jennifer's son influenced her belief about student learning. Jennifer's son was a toddler, and he taught her how mathematics learning was not always observable. She explained:

> I know that from the first floor to the second floor of our house there are 18 stairs because every time I carry him up the stairs we count the stairs 1, 2, all the way up to 18. I never really realized he was paying attention until one day he counted the stairs, too. I was just shocked that my 18-month-old was internalizing those numbers and all of a sudden he was able to say them on his own. I was impressed with the ability of a child so young

> because he was my first child and I had never experienced that learning curve with a young child. (inter#3)

She discovered he was internalizing her words, and she saw how this could be connected to her students:

> And so I realized with my students the same may be true. Even though I feel like I am saying it over and over and it is not sinking in, eventually all of a sudden it is going to click just like with my toddler. (inter#2)

Jennifer realized that mathematics learning is not always observable, and even if you cannot see it happening, it could exist for the student.

When her son is older, Jennifer said that she might utilize him to determine the best teaching practices for her students. She stated, “I could totally see how if he was closer to their age, seeing how he thinks about things and seeing how he is doing problems would be really insightful” (inter#2). Thus, Jennifer’s son could possibly influence her future mathematics teaching practice.

Schooling Experiences

Past teachers. Jennifer’s initial beliefs about learning mathematics and teaching mathematics were influenced by her experiences with her past teachers. Jennifer enjoyed her mathematics courses and teachers. She stated, “I always liked math. I think if you were my math teacher, you by default were my favorite because you taught my favorite subject” (inter#2). When asked what influenced her most about those mathematics teachers, she said they “motivated us with competition and rewarded us with candy. Both of which I valued as a kid” (KFABC). The teachers’ motivation of games and sweets reinforced Jennifer’s belief in mathematics needing to be fun to be meaningful.

However, Jennifer acknowledged that what she enjoyed and valued as a student was not necessarily what she valued as a teacher. She explained:

> I never really liked the classes where you had to act things out or do creative projects because I was never a creative person. I would just so much rather do worksheets than have to make some skit or some play. I would be like, “Aww.” But now as a teacher, I am like, you don’t do worksheets. You make it fun. We do creative hands-on things. So what I liked as a kid is not necessarily what is best for kids. (inter#1)

Jennifer learned to value hands-on activities over worksheets and competitions, but these activities were some of the first influencing factors to make Jennifer enjoy mathematics.

Teacher Education Experience

Mathematics content courses. Jennifer identified her mathematics content courses during her teacher education program as influential to her beliefs about mathematics, but again this influence did not manifest itself until after she started teaching. These courses, as she described them, “were not teaching how to teach math; it was teaching us how to understand math in a different way than we had ever been taught” (inter#2). They challenged her views about number sense and how mathematical concepts could be decomposed. After she saw the importance of implementing problem solving activities in her class, she explained:

> It changed the way I thought about math because I learned very traditional algorithmic formulas like $a + b = c$. Then that completely turned that upside down. It made me a stronger math teacher because it made me learn to think about math in different ways than I had ever been taught before. (inter#2)

The mathematical content courses helped to shape Jennifer’s current view of the nature of mathematics by having her reassess her past views on mathematics.

Mathematics methods courses. Jennifer's beliefs about teaching mathematics were influenced by her mathematics methods courses during her teacher education program. However, the methods courses were not influential until later in her teaching career.

Jennifer admitted that initially when she first started teaching she would ask other teachers what she needed to do for her students, but later she came to realize how important the information was that she was taught in her program. Jennifer was motivated to reflect on her beliefs about the nature of mathematics. From her reflection, she considered how her methods courses "forced us to really think about math - not just accept the algorithms" (KFABC). After teaching for several years, she understood why the methods courses challenged her beliefs about the nature of mathematics, and "forced" her to view mathematics not as a set of rules but rather a problem solving process.

Jennifer's beliefs about teaching mathematics were influenced by many of the activities implemented in the methods courses. While she taught, she reflected on the instructional strategies advocated in her methods courses. Jennifer said:

> It was valuable when they did lessons with us and showed us how much fun it could be, so we were inspired to do the same things with kids. It was way different than sitting in some math instructional course where everyone was spouting out research or whatever, but rather they modeled those skills. This really stuck with me. (inter#2)

The methods instructor modeled teaching techniques that "inspired" Jennifer to change how she viewed mathematics teaching that consequently influenced her teaching practice. She jokingly stated her undergraduate education did have a significant impact on her beliefs, but "it just took me 10 years to get there" (inter#3).

Professional development. When asked what she believed was the largest influence on her beliefs about teaching mathematics, Jennifer responded that it was her professional development opportunities. While she taught in Arkansas, she participated in a workshop on Cognitively Guided Instruction (CGI). Jennifer explained:

> I think with CGI my biggest takeaway was the idea that less is more. You don't have to do a page of problems. You don't have to do so much to know that the kids get it, to have rich discussion, or see what they know. One problem can be the basis for a whole lesson. That one problem can take 30 minutes and that is ok. (inter#2)

The 7-day workshop had such a large influence on Jennifer's beliefs about student learning and mathematics teaching because she was given the opportunity to watch elementary teachers successfully implementing the CGI activities in their own classrooms with students very similar to the ones she taught. This was the professional development that made her change her view of herself from the "bearer of all knowledge" to a "coach" (inter #2). She explained the experience made her:

> realize if I just stand up there and explain it, there are a few kids that will learn that way, but there are whole bunch that don't. Maybe I will apply to the really diligent visual learners, but I am losing the rest who actually need to do them to learn from the process. (inter#2)

Observing teachers and students implementing CGI successfully influenced how Jennifer taught and how she viewed her students' learning.

Teaching Experience

Coworkers. In Jennifer's experience, coworkers had many different influences on her mathematics teaching practice. First, in some cases coworkers set the standard for the mathematics teaching in the school. Because Jennifer worked in many different school environments, she noted:

> I have always felt like my first year at somewhere I was kind of proving myself not only to my administration, but to my coworkers and parents. I was trying to build a strong reputation, and if you go in completely different, you don't know how you will be received. So I have always gone in and tried to feel it out how things are going and start off that way, and then, as I felt it was appropriate, kind of deviate, as I needed to. (inter#2)

She had to work with her fellow teachers, and Jennifer expressed a need to learn the schooling environment to know what was expected of her as a teacher.

Second, coworkers were an informative resource to learn about mathematics teaching. When asked to whom she would go if she had questions about teaching mathematics, Jennifer chose her coworkers. At the time of this study she taught mathematics for all the fifth grade students in her school. Jennifer worked in a collaborative teaching environment that supported the co-teaching model. She had two different teachers push in her class, one of which was a special education specialist and the other was a mathematics specialist. Thus, each of the teachers in her class could serve as a resource for information.

Standards. Teaching standards heavily influenced Jennifer's mathematics teaching practice. Jennifer explained:

> I would say the state or county going to standards-based teaching has had a significant impact on what I teach, when, how, and why. When I first started teaching, I remember just kind of asking around, "What should second graders be doing?" We had textbooks that were second grade textbooks, and we taught the lessons that were guided by the

> textbook, and we took that as what the kids should learn that year. Now I feel like our standards are our starting grounds for everything. I would never just teach something because it was in a book. I think the shift toward standards-based instruction significantly impacted the way I teach now. (inter#2)

This shift toward standards-based instruction changed her teaching practices. When she first started teaching, she implemented big thematic units on topics such as whales. After standards were emphasized in her state, she changed her teaching practices to support students' learning of the goals represented in the document. She explained, "Every lesson I do needs to be with a purpose of helping them to deepen their understanding or show mastery of that standard. Do I really need the Skittles for them to understand? Ah, that would be a stretch" (inter#1). Jennifer equated using Skittles with fun, so she no longer believed fun should be the sole focus of the lesson. Rather, the mathematical concepts should be center stage. Thus, standards changed how Jennifer taught mathematics.

Students. Jennifer had the opportunity to teach in three different states with a variety of different students, and from that experience she developed her view of how students learn mathematics. Jennifer said:

> Eleven years later, I am still amazed by the unique and creative ways that students solve problems. Some are effective and efficient, others not so much - but it's still fascinating to see how the human brain can process the same problem in so many different ways. (KFABC)

Jennifer learned the value of having students share these amazing and unique ideas with others, and she saw how everyone could learn. She taught in rural Arkansas and learned:

> It is no secret that these kids in [the affluent district where she was currently teaching] have a lot of different resources. They hear different vocabulary at home, and they have a lot more support with their homework than the other kids in Arkansas did. It was just different, but those kids were doing the same level and quality of work that I am getting here. (inter#3)

Technology. Technology did not influence Jennifer's beliefs about mathematics, but it did influence her teaching practice. At each school she had some form of a projector for her computer. Jennifer described how this technology allowed her to be "ready before the class even started" (inter#2). She explained, "I'm not losing transition time writing things on the board or reading out names. It's just ready" (inter#2). She admitted to not using a lot of different forms of technology, but she used her interactive white board every day in her mathematics teaching as an organizational device.

Recession. Jennifer identified the recession as an influence on her teaching practice. Jennifer experienced a change in her student population that she attributed to the nation's economic problems. Jennifer said:

> [Her current county] is such an expensive place to be that if you lose your job or if money gets tight, they have to leave [there]. They can't afford the houses there. They can't afford the rent there. They can't afford to stay there. The families that we are losing are the lower income families. The new students that we get, it's like, "Oh her dad is the new gymnastics coach at [the university]" or, "Oh her dad is head of the new [manufacturing] plant in [the county]" or, "His dad is the head surgeon at [the local hospital]." Every kid that is coming in is coming into the million-dollar house in [expensive subdivision]. (Focus Group)

Jennifer's student population changed, making it necessary to change how she taught. The students had more resources available to them such as computers, tutors, and parental support. If students were having difficulty with concepts, their families would fund outside assistance to help their students learn the concepts. Therefore, Jennifer observed a rise in the number of students in her higher-level classes. To meet the needs of these new students, Jennifer implemented different forms of differentiation by enacting more tasks with high-level of cognitive demand. By differentiating, Jennifer was still able to meet the needs of her lower level students but also focus instruction on the higher-level students' mathematical development.

Personality Traits

Confidence. Another influencing factor on Jennifer's teaching practice was her confidence in herself to enact her beliefs. Jennifer's first job was at a school that rarely hired inexperienced teachers, and this caused her to question her own teaching practice. She explained:

> When I first started teaching, I did what the other teachers on my grade level were doing. Like, this is how my mentor does it, and she is, like, the most awesome teacher in the whole school, so of course I am going to do what she is doing. She did the worksheets. Our parapro tore out chapter one and stapled it together, and we did a couple of papers each day. A couple of years later, I started to figure out that maybe now that I have more confidence, more experience, I would feel more willing to take my own risks. Do things my own way. When, certainly, my first year of teaching I didn't feel quite that confident. (inter#1)

Jennifer said that this lack of confidence subsided after she was able to back up her ideas. She explained this came from personal experience teaching and watching her students learn. The confidence came from being able to express why she believed her teaching practices were best for her students and being able to express why her mentor teacher's teaching practices were not as effective. She had to build the confidence in her views about mathematics teaching and learning. Jennifer stated:

> If a principal asked why I was doing this lesson now, I would say because this lesson supports our fifth grade standards. Because that is what we do. Our entire lesson supports the fifth grade standards, and then I could provide loads of documentation to verify that in terms of work samples and standards assessment tools. I could certainly justify my reasoning behind the lesson a lot more professionally now than before. Like before, we would literally go through the book chapter by chapter, where now every lesson is based on the standards and our assessments are aligned to those standards (inter#3).

Jennifer's self confidence allowed her to teach the way she believed was best for her students.

Personal motivation. Jennifer was personally motivated to do her best. Her mother would give her a "hard time" about doing her work (inter#2). She explained, "She says that I was a nightmare because I would do my homework, but it wouldn't be neat enough so I would have to rewrite it. Or I wanted to recheck everything" (inter#2). It was not her mom pushing her to do the assignment in a certain way; it was her own personal motivation to be the best student possible. As she grew up, she took courses with other motivated people, which influenced her to study hard. Jennifer explained, "I was determined that I was going to get just as high of a score on the AP [Advanced Placement] exam as anybody in that class" (inter#2). In the end, what had the largest influence on her teaching practice was her personal motivation to be a good teacher. She grew as an educator since her second year of teaching because of this motivation. Her personal motivation led her to go back to school for her master's degree and led her to use her professional development experience in her class. Jennifer stated:

> I guess it goes back to the fact that I want to be the best teacher possible for my students, and as often as possible I don't take the easy way out. I don't just give the kids busy work because I need to work on my report cards. I don't just do whatever. I put a lot of pressure on myself to be the best at what I do. (inter#2)

Jennifer's personal motivation influenced her to learn more and strive to be the best mathematics teacher possible.

CHAPTER 7

DISCUSSION

In this chapter, I describe how I modified my initial model of factors affecting beliefs to account for new factors that emerged during my data analysis. I classify each of the factors named by the participants using the new model and identify how the factors influenced a teacher's teaching practice or beliefs. Finally, I looked across Jayne's, Laura's and Jennifer's cases to describe the commonalities in factors that influenced their beliefs or teaching practices.

Categorization of Factors

As noted in Chapter 2 I developed a model of factors affecting beliefs based on prior work by Richardson (1996) and Raymond (1997). I melded their frameworks together to create a new framework, Initial Model of Factors Affecting Beliefs (see Figure 14) and used this framework to analyze the data from my pilot study and this study.

The four original categories of personal experiences, school experiences, teacher education experiences, and teaching experiences described external influences on beliefs, and my participants identified elements in all four categories. After analyzing my data, I made adjustments to the framework to account for new factors that emerged from this study. In particular, the participants identified a factor relating more to their internal personality traits rather than an event or a person in their lives. Identifying personality traits as a factor is consistent with Day et al.'s (2007) finding that emotional context influences teachers' formation of their identity. Thus, I constructed another category of factors to account for participants' personality traits that influenced their beliefs.

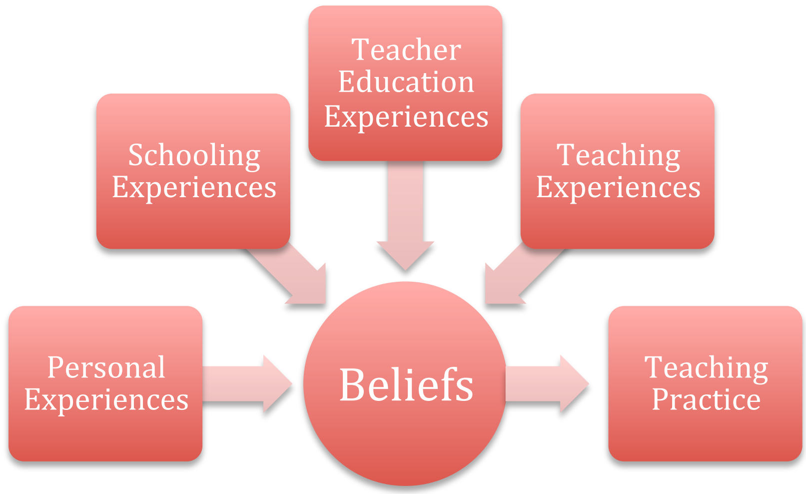

Figure 14. Initial model of factors affecting beliefs.

As shown in Figure 15, I named this new category *personality traits* because it accounted for the participants' views of themselves and how they should act. In addition, the participants identified factors as influencing their teaching practices more often than their beliefs. The participants stated that their beliefs were not always changed by events in their lives, but their teaching practices were influenced significantly. Because each of the participants identified events that affected her teaching practices, I revised the model to show that the factors could influence beliefs or teaching practice.

In the new model some categories of factors, such as personality traits and teaching experiences, have an arrow pointing only to teaching practices. The arrow represents my participants' statements that the specific factors from that category influenced their teaching practice and an absence of any evidence that their beliefs about the nature of mathematics, teaching mathematics, or learning mathematics were affected by these factors. The literature suggests (Borko et al., 1992; Raymond, 1997) that practices influence beliefs and beliefs influence teaching practices; therefore I placed a two-way arrow between beliefs and teaching practice even though my participants did not directly make this connection.

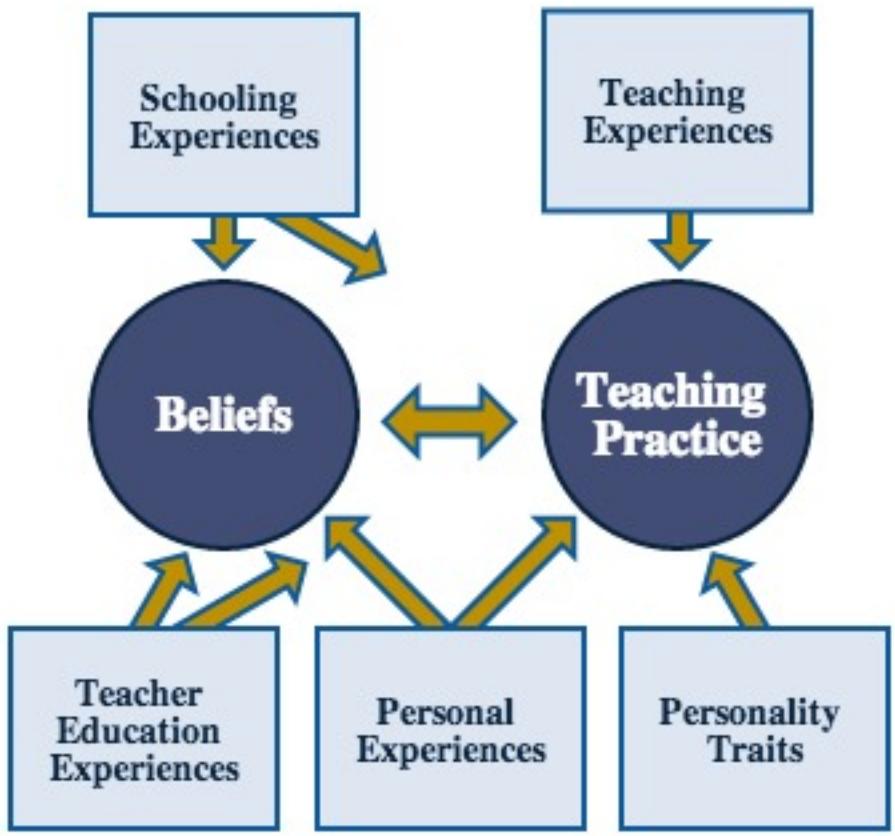

Figure 15. Model of the five factors affecting beliefs or teaching practice.

Within the five categories, I identified the factors shown in Table 10. Laura, Jayne, and Jennifer described a variety of these factors during their interviews, with each of the factors below being named by at least one participant as influential. Each participant was educated at the same university, was married, had children, and taught in elementary schools for at least 10 years. Perhaps because of these similarities, many of the factors identified by one participant appeared across all three cases. In the following sections, I describe how I mapped each factor to participants' beliefs about the nature of mathematics, teaching mathematics, and learning mathematics or to her teaching practices.

Table 10

Factors Influencing Beliefs or Teaching Practice

Personal Experiences	Schooling Experiences	Teacher Education Experiences	Teaching Experiences	Personality Traits
❖ Parents ❖ Husbands ❖ Children	❖ Past Teachers ❖ Past Textbooks	❖ Mathematics Content Courses ❖ Mathematics Methods Courses ❖ Professional Development	❖ Administrators ❖ Coworkers ❖ Past Students ❖ Standards ❖ Past Teaching ❖ Technology ❖ Recession	❖ Confidence ❖ Personal Motivation

Mapping Factors to Beliefs about the Nature of Mathematics

Changes in beliefs about the nature of mathematics occurred during the participants' personal experiences, schooling experiences, and teacher education experiences. As shown in Figure 16, they identified six factors as influencing this belief.

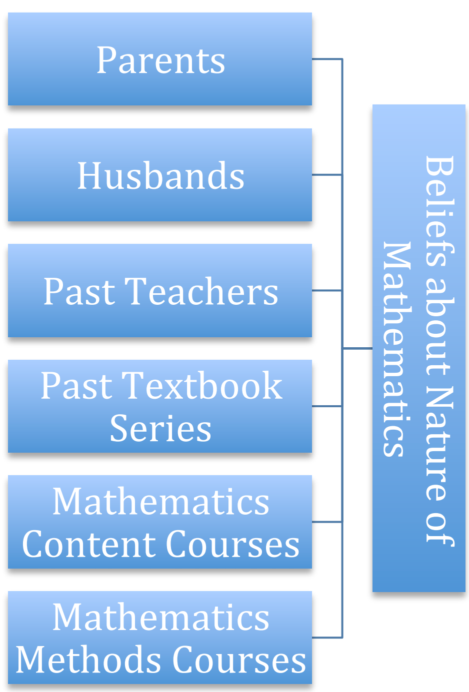

Figure 16. Factors influencing beliefs about the nature of mathematics.

All three participants identified their parents as individuals who helped reinforce their beliefs about of the nature of mathematics. The parents did this by emphasizing the connection between mathematics and real world situations. Laura's father taught her different concepts in mathematics through the use of carpentry activities. Jayne and Jennifer practiced mental mathematics with their mothers while calculating prices at grocery stores. Even though they experienced most of their mathematics in the classroom, their parents influenced how they came to understand mathematics as a problem solving activity through the use of real world situations.

Laura and Jayne identified their husbands as continuing their parents' influences of viewing mathematics as problem solving. Both husbands had careers that used higher-level mathematics. At night, both couples discussed their days, and mathematics was a common topic. Through their discussions, the participants became more aware of how mathematics was used in other fields and how mathematics was viewed in an applicable manner.

The participants' K-12 teachers had the largest influence on their initial beliefs about the nature of mathematics. Each participant identified that she came from a traditional classroom environment where mathematics was taught as a set of rules that she needed to memorize. They identified themselves as "good at math," meaning they made As in their mathematics courses in school, yet Laura explained this meant they were able to memorize and repeat facts and procedures very well. Laura and Jennifer both initially held an instrumentalist view of mathematics that was fostered by their past teachers. Because the participants had over 12 years of educational experiences prior to their teacher education program, their initial traditional beliefs about the nature of mathematics were strongly rooted in past teachers' actions.

Laura identified the textbook series used during her K-12 education experience as being influential to her view of mathematics as a discipline. Her school chose to implement a spiral, scripted textbook series, which she believed reinforced traditional teaching strategies and affected her past teachers' teaching styles. Laura had to continue teaching with that textbook series after she began full time teaching, but she had other influencing factors that helped her combat some of the messages that textbook series portrayed. Like her past teachers, Laura's textbook series helped her construct her views of mathematics in schools prior to her teacher education program; thus it too was very influential in her initial beliefs about the nature of mathematics.

Once the participants took their content and methods courses in their teacher education program, they identified the instruction as causing them to "challenge" their previous views on mathematics. Both Laura and Jayne identified their methods courses as the most influential factor in their construction of all of their beliefs. As Laura explained,

> When I was in her [Dr. Mathis's] class, I recognized that I was thinking a different way about the algorithm, and I do remember constantly thinking in her class, "Yeah right. I am probably never going to use manipulatives in the fourth grade because no one uses base 10 blocks in fourth grade." But, I did buy them and did use them because my kids were not learning the way Saxon said magically should be happening. (Focus Group)

These courses allowed them a place to reflect about their past understanding of mathematics fostered by their past teachers and textbooks. Through the reflection and content of the methods courses, the participants changed how they viewed the subject.

Mapping Factors to Beliefs about Teaching Mathematics

Beliefs about teaching mathematics had many influencing factors from different points in the teachers' careers. Their initial understanding of teaching came from their K-12 educational experiences. After they took their methods and content courses and started their careers, they had many other examples of teaching to compare with their past experiences. As shown in Figure 17, the participants named three factors as influencing their beliefs about teaching mathematics.

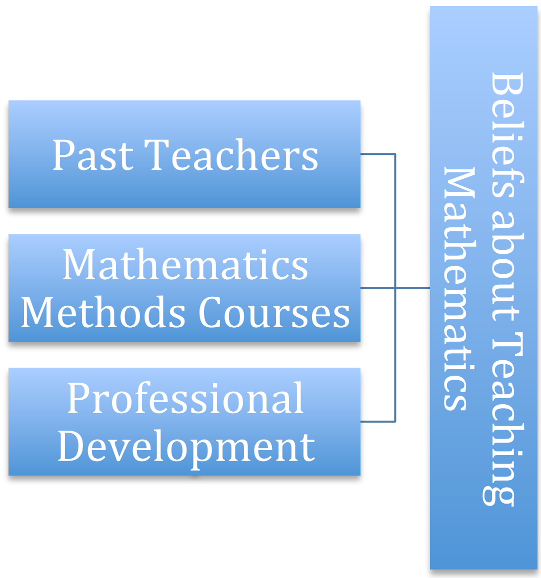

Figure 17. Factors influencing beliefs about teaching mathematics.

Before the participants taught their own classes, they had notions about how to teach formed from their own experiences in the educational system. As students, they observed various teaching styles and were able to experience the effectiveness of each of the teaching practices on their own learning. These experiences were so influential that the participants could identify specific past teachers who helped or hindered their learning of the subject. Therefore, their initial beliefs about teaching mathematics were formed from the teaching practices they found most effective for their own learning.

All three participants identified their past teachers as influencing their beliefs about teaching mathematics. These teachers' main form of instruction was a lecture format. Prior to their teacher education program, the participants believed lecturing was how mathematics was supposed to be taught because that was how they were instructed.

In their teacher education program, the participants were asked to look at teaching in a new way, which was different from what they experienced during their K-12 educational experiences. The three teachers said their mathematics methods courses introduced them to "how teaching was supposed to be done" (inter#1, Jayne). Jayne additionally stated that Dr. Mathis's courses were the only classes from which she could still use the materials today. She explained, "I always looked forward to getting out of my other classes to make it to her class. It was like one of the few classes where I felt as if it was not a waste of my time. It was like 'Now I am going to learn something'" (inter#2). Dr. Mathis challenged their ideas of teaching and made them think about what they were doing in a new way, which influenced their beliefs about teaching mathematics.

Of the three participants, Jennifer was the only one who identified professional development opportunities as influencing her beliefs about teaching mathematics. Jennifer participated in a CGI workshop, which she viewed as the largest influencing factor on all of her beliefs. She stated that the workshop gave her evidence of what to teach and showed her how to teach using classrooms with real students. Jennifer stated that the workshop changed her ideas of what a classroom should look like and allowed her to see that a single problem could stimulate discussions and mathematical ideas in a new way.

Mapping Factors to Beliefs about Learning Mathematics

The participants' initial beliefs about learning mathematics were formed during their experiences as learners of mathematics, but other factors came into play as they grew as educators and mothers. As shown in Figure 18, the participants identified four factors as influencing their beliefs about learning mathematics.

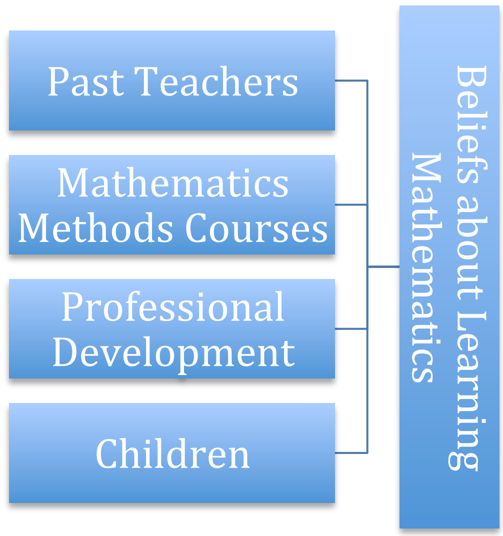

Figure 18. Factors influencing beliefs about learning mathematics.

As students, the participants learned from their teachers and their school friends how to learn mathematics. They learned how to take notes, memorize steps, and ask for help from others; thus they learned how to succeed in the traditional classroom environment. However, they also learned what teaching practices were not effective for all learners. They saw how difficult it was to learn mathematics as a passive recipient of knowledge, so many of the participants initially believed in actively constructing knowledge because that was how they learned best.

Once they experienced their teacher education program, the mathematics methods courses reinforced their beliefs about the active construction of knowledge by providing tasks and strategies to implement in their own classrooms. These activities included using manipulatives to teach mathematics conceptually. Their methods instructor was identified as helping to reinforce how to build students’ conceptual understanding of mathematical topics. After they became full time teachers, they implemented many of the activities they learned in those courses.

Through Jennifer's professional development opportunities, she learned how to implement specific mathematical tasks to help her students participate in mathematical conversations and construct their own understanding of mathematical topics. She always believed that students should actively be engaged in mathematics, but she did not know how to implement tasks supporting this belief. The CGI professional development provided the support needed to reinforce Jennifer's beliefs about active learning and provided practical ways to enact this belief in her classroom.

The participants' children also influenced their views on students' learning. Having a child at home allowed them to study how children develop mathematical understanding. Each participant stated that having children allowed her to notice different aspects about how kids learned, which she said she would not have known otherwise. For example, Jayne and Jennifer stated that they were not aware of how fast students initially construct number sense when given appropriate stimuli at home. Because they personally participated in the development of their children's mathematics, they viewed student learning differently.

Mapping Factors to Teaching Practice

Many different factors in teachers' lives affected how they implement activities in their classrooms. For example, Laura's administrator mandated that each grade should implement the same lesson on each day from a specified textbook series. By restricting teachers' planning, Laura's administrator severely impacted how she taught her students, but it did not change the way she believed she should teach. As shown in Figure 19, there were 10 factors that influenced the teachers' instructional practices.

Leatham (2006) described how outside demands could cause teachers to implement practices that appeared to differ from the teacher's beliefs, and I observed this phenomenon in

Laura's case. Her administrator's restrictions caused her to change the way she taught because he wanted everyone to try the new textbook series before changing the written curriculum. The administrator took this drastic action because he thought some teachers were too dependent on worksheets. Thus, the combinations of coworkers' influence and administrator's decisions caused Laura to change her teaching practices to align with expectations.

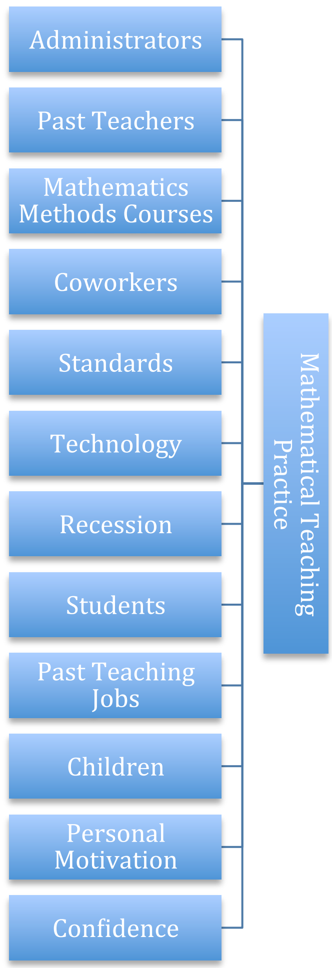

Figure 19. Factors influencing mathematics teaching practice.

My participants' past teachers and mathematics methods courses influenced their teaching practices as well. Jennifer and Laura described how they initially began teaching similarly to how their past teachers taught. However after observing how ineffective their traditional teaching practices were for their students, they changed their practice to implement activities advocated in their mathematics methods courses. After entering the workforce, Jayne indicated she was able to immediately implement many activities she learned from her methods courses in her classroom like using snack-sized bags of candy to help students understand data analysis. Across Laura's 10 years of teaching practice, she used her mathematics methods courses notebook to help her determine how to teach different mathematical concepts such multiplication. Thus, the participants' past teachers and mathematics methods courses influenced their teaching practices over time.

Coworkers initially influenced Jennifer's teaching practice. When she first started teaching, she lacked confidence to do what she thought was best for her students and therefore implemented activities given to her by other experienced teachers whether or not they matched her beliefs about teaching mathematics. As a first year teacher, she did not think she was able to contradict practices implemented by more experienced teachers. They each had coworkers with whom they would plan lessons, discuss mathematical ideas, and share practices. By working with fellow teachers, their views on teaching were challenged through group reflection and discussion. The coworkers served as a non-threatening resource that they could go to if they had questions about the methods or content of a lesson. Through working with others they learned new concepts and changed how they saw others.

The three teachers stated the state's standards influenced what they taught and how they thought about teaching their students. Because of the big push for standardized testing, they had to change the content in their lessons to ensure their students could perform well on state-mandated tests. Jennifer stated that she implemented different activities to help students become more familiar with the multiple-choice format of the tests. But as she explained, the activities focused more on learning how to take a test rather than learning mathematics; thus her beliefs about how to teach mathematics did not change.

Both Jayne and Jennifer were in schools with many technological resources that helped them teach different concepts. Jayne used her interactive white board every day to show videos to help reinforce different mathematical topics, but she viewed the technology as a tool. Jennifer too used her interactive white board every day, but it was more as a classroom management and organizational resource. Jennifer believed, like Jayne, that it was a tool that changed how her classroom looked and ran but did not change her beliefs about teaching or learning.

Economic issues that their communities faced also affected how the teachers taught. All three teachers stated that the 2007-2009 economic recession caused them to change how they taught their classes because their student population changed. Jennifer saw a rise in higher-achieving students because her community attracted families with higher incomes. Laura and Jayne saw a drop in students' basic knowledge, which they believed was caused by lower parental involvement. The teachers had to focus on meeting their students' emotional and physical needs before they could meet their students' mathematics needs. When they did focus on the mathematics, they needed to assess their basic skills first. They no longer could assume the children received background knowledge about specific topics at home. Therefore, the recession caused the participants' teaching practices to change.

Students also served as an influence on the teachers' teaching practices. The teachers experienced what worked best for their students and changed their teaching according to their observations. As Jayne stated, she taught based on practices she found to be effective for her students. If she saw something not working, she changed her teaching to meet their needs.

Because all three of the teachers were very self-motivated to be the best teacher possible, this became a continual reflection process throughout their 10 years of teaching.

Over the 10 years of teaching, the participants observed their students developing strategies to help construct their conceptual understanding. Laura and Jennifer taught in multiple grade levels. By observing students at different stages of mathematical learning, they were able to anticipate misconceptions students might have about concepts and construct activities to better suit the needs of their students. They gained pedagogical knowledge, which influenced how they taught their students.

Each participant had a vested interest in her own child's mathematical development. By personally observing their children's mathematical understanding, they learned what teaching practices were most effective for different concepts. For example, Jayne taught her son different addition strategies by relating the concept to real life situations such as firefighting. Jennifer helped her son to count using stairs, and Laura taught her daughter mathematical tasks that had her reflect on the effectiveness of the activity. By knowing what worked best for their own children, they were able to teach concepts in new ways to help other students succeed.

Personal motivation and confidence were named as factors that influenced the participants' teaching practice. They were internally motivated to be the best teachers possible; therefore they pursued their master's degrees and participated in and instructed in professional development opportunities. The participants took what they learned from their methods courses and content courses in their educational experiences and reflected on the practices while they taught. Laura stated that she referred to her notebook from her methods courses to see how Dr. Mathis taught certain subjects. Jayne and Jennifer were motivated to reflect back on those experiences as well. Jayne stated in her interviews that she still used many of the activities she learned in her methods courses, and Jennifer explained that initially she did not reflect on the practices but later came to see what was taught in those courses to be useful.

Discussion of Mapping

In this section, I identify which factors had the greatest influence on the participants' beliefs, and I identify the categories of factors that influenced beliefs or teaching practices as shown in Table 11. Each checkmark in Table 11 means that at least one participant named that factor as being influential to her teaching practices or her beliefs about the nature of mathematics, teaching mathematics, or learning mathematics. Researchers have shown that beliefs can influence teaching practices, and teaching practices can influence beliefs (Borko et al., 1992; Raymond, 1997). The participants' beliefs and teaching practices were influenced by a variety of factors from each category, and in this section I identify the impact of each category of factors.

My participants identified their personal experiences, past schooling experiences, and teacher education experiences as influencing both beliefs and teaching practices. As shown in Table 11, teaching experiences and personality traits influenced only teaching practice. However, I am not claiming that teaching experiences and personality traits could not influence individuals' beliefs; rather my participants did not name any factors from these areas as affecting their beliefs about the nature of mathematics, teaching mathematics, or learning mathematics.

Past schooling experience influenced all categories of beliefs and teaching practices. As Richardson (1996) stated, teaching is a unique profession that has its employees coming into the workforce with preconceived notions formed from their past experiences as students. My participants' initial beliefs were constructed from being in the classroom observing other teachers and experiencing the teaching from the student's perspective.

Table 11

The Five Categories of Factors Influence on Beliefs and Teaching Practice

		Beliefs About:			
	Factors	Nature of Math	Teaching Math	Learning Math	Teaching Practice
Personal Experiences	Parents	✔			
	Husband	✔			
	Children			✔	✔
Schooling Experiences	Past Teachers	✔	✔	✔	✔
	Past Textbooks	✔			
Teacher Education Experiences	Mathematics Content Courses	✔			
	Mathematics Methods Courses	✔	✔	✔	✔
	Professional Development		✔	✔	
Teaching Experiences	Textbooks				
	Administrators				✔
	Coworkers				✔
	Past Students				✔
	Standards				✔
	Past Teaching				✔
	Technology				✔
	Recession				✔
Personality Traits	Personal Motivation				✔
	Confidence				✔

Lastly, the participants' mathematics methods courses influenced their teaching practices and their beliefs about the nature of mathematics, teaching mathematics, and learning mathematics. They were able to identify how the courses influenced how they viewed the subject because it challenged their previous views constructed from their past schooling experiences. Therefore, 10 years after their teacher education program, the participants still viewed their mathematics methods courses as influencing their beliefs.

CHAPTER 8

SUMMARY and CONCLUSIONS

Summary

I explored the experiences of three elementary school teachers who taught for over 10 years to investigate their belief change and the influences on their teaching practices and beliefs about the nature of mathematics, teaching mathematics, and learning mathematics. They attended the same undergraduate teacher education program and were followed from their junior year of college into their second year of full time teaching to investigate their belief construction. By investigating these teachers 10 years after they graduated from their teacher education program, I was able to classify their beliefs about the nature of mathematics, teaching mathematics, and learning mathematics and to compare them with their beliefs from their second year of teaching. I was able to determine how their beliefs changed and what specific factors influenced their beliefs and teaching practices.

By conducting 3 personal interviews, 3 classroom observations, 1 focus group interview, and 2 surveys, I determined that the three participants varied in the stability of their beliefs from their second year of teaching to their 10th year. One participant did not experience a belief change from her second year of teaching until her 10th year of teaching. She continually taught in the same school for all 10 years and kept her overarching belief in doing what was best for her students throughout that time. Her strong overarching belief supported the beliefs she constructed after her second year of teaching, thus allowing her beliefs to stay constant.

Another participant experienced a change in her beliefs about the nature of mathematics during her teacher education program. She also experienced a change in her teaching practice over 10 years, which she attributed to her administrator's demands. She experienced the most administrative control over her classroom, but she also experienced the most influence from the teacher education program. From her lack of direct control of her teaching practices, she was able to reflect on the benefit of the practices implemented in her teacher education program.

The third participant experienced a drastic change in beliefs from her second year of teaching until her 10th year. She changed from having an instrumentalist view of mathematics to a problem solver's view. She also changed from being an explainer in her classroom to being a facilitator. Both of the changes, she stated, were influenced by her involvement in a Cognitively Guided Instruction workshop. From the professional development workshop she was able to see how different activities could help her students succeed. Because she taught at different schools across the country, she had opportunities to work with a variety of students in different contexts and interact with a variety of teachers. Thus, she experienced a multitude of changes over her 10 years of teaching.

After determining the participants' beliefs, I identified specific factors that influenced their beliefs over time. The teachers named factors from their personal experiences, past schooling experiences, teacher education experiences, and teaching experiences, all of which were previously identified by Raymond (1997) and Richardson (1996). They also specified personal characteristics about themselves that influenced their beliefs, and I created the category Personality Traits to account for those factors.

Next, I constructed a mapping of the factors the participants identified to the beliefs or teaching practices they influenced. From this mapping, I found that the category of factor (i.e.

personal experiences, school experiences, etc.) did not determine the beliefs or teaching practices it affected. The areas with the greatest influence on my participants were their past schooling experiences and their teacher education program. How they were taught as students affected how they viewed the nature of mathematics, teaching mathematics, and learning mathematics as beginning teachers. Their past schooling experiences, however, were not the major factor influencing their teaching practices 10 years after entering their teacher education program. They identified their teacher education program and professional development as having the largest effects on their beliefs and practices.

Conclusions

By constructing the mapping of factors to beliefs, I drew specific conclusions from the influence of factors. I found that the participants' teacher education program had a long-term impact on them even when the influence was not initially identifiable. The participants demonstrated how specific life situations changed their beliefs about mathematics over time, and I observed that economic situations were an influential factor on teachers' classroom practices.

Delayed Influence of Teacher Education Program

Some researchers have found that teacher education programs have little effect on preservice teachers' teaching practices and beliefs (Raymond, 1997; Scott, 2005). The researchers observed little to no change in the preservice teachers' beliefs at the end of their teacher education program (Raymond, 1997); and after they enter the teaching profession, the researchers found many teachers regress back to beliefs constructed prior to their teaching education program (Scott, 2005; Swars et al., 2009). However, this study suggests that teacher education programs can influence teachers' beliefs years later even if their program did not initially influence them.

Raymond (1997) speculated that teacher education programs might not initially have a large influence on beliefs. My participant who initially did not find her teacher education program as influential demonstrated that teachers might need the gift of time to allow them to reflect and become aware of their beliefs. Each preservice teacher filtered her teacher education program through her personal perceptions, influencing how she translated events, which was consistent with Grant et al.'s (1998) findings. Thus, some teachers might need more experiences with students to highlight how their beliefs might be contradictory to the realities of teaching. My participant's construction of beliefs suggests more time might be needed to fully observe a belief change in many preservice teachers.

Long-Term Influence of Teacher Education Program

The participants' teacher education program had a long-term influence on their beliefs. Across their 10 years of teaching, they either kept the beliefs they constructed during their teacher education program or progressed in their beliefs because of information learned during that program. The preservice teachers experienced two mathematics methods courses and three content courses, and the lessons learned from these experiences were lasting.

The participants noted that they still implemented activities and lessons that were advocated in their mathematics methods classes throughout their 10 years of teaching. They explained that the beliefs they constructed during those courses still held true. The participants said the classes had a lasting impact on their beliefs.

Also, the participants stated that their mathematics content courses had a long-term influence on their beliefs. They explained that while preservice teachers might gripe about the mathematics content courses because they required preservice teachers to explain their thinking and understanding of the foundations of mathematical concepts, they found the courses to be an extremely valuable experience that helped them have a long-term belief change about the nature of mathematics.

Changes in Life Roles

Research has shown that personal experiences, schooling experiences, and content and pedagogical knowledge can change beliefs (Richardson, 1996), and in this study, I observed how changing roles influenced teachers years after their teacher education program. This is consistent with Day et al.'s (2009) findings that teachers' personal identity influences their effectiveness as teachers. All three participants experienced many of the same life-changing events after leaving their undergraduate program. Their evolving personal roles changed the way they viewed mathematics.

First, they progressed from being students to becoming practicing teachers. Next, the participants each evolved from a single woman to a wife to a mother. Finally, they transitioned from being beginning teachers to experienced teachers. When the participants changed their roles as teachers, wives, and mothers, they viewed their teaching practices or beliefs about the nature of mathematics, teaching mathematics, or learning mathematics in a new light because of the added experiences.

Economic Situations

All three participants identified the economic situation between 2007 and 2009 as influencing her teaching practice. The recession was a completely unexpected element influencing my participants' teaching practices that could not have been predicted in their teacher education programs and was not connected to teacher education, professional development, or any other usual influences on teaching. In two cases, the socioeconomic status of the students declined, leading the teachers to provide basic necessities, such as snacks and nap time, for their students and leading them to spend more time reviewing skills that they previously expected to be taught at home. For the other case, the recession led to an increase in the socioeconomic status of her student population (because less affluent families were forced to move out of her county), so she found herself needing to provide more challenging instruction for her students.

My participants' views of the recession's effects were consistent with the findings from the U. S. Bureau of Labor Statistics (BLS, 2012). Because of the increase in unemployment, more children were living in poverty (Isaacs & Healy, 2012). As of the Urban Institute's 2012 reports, the overall poverty levels for many families had not changed since the start of the recession. With many parents subjected to mass layoffs, the student populations changed, reflecting this economic situation.

As students changed, teachers' teaching practices changed to support the needs of their students. This occurred through helping their students meet their basic needs of sleeping and eating to ensuring their basic mathematical understandings were taught. Economic situations influenced parents and their children, thus influencing the teaching field for future generations.

Implications

This dissertation provided evidence suggesting that teacher education programs could influence teachers years after they graduated from their programs. As I described above, some researchers concluded that teacher education programs were not influential because teachers did not show a belief change immediately after the program (Raymond, 1997; Scott, 2005). However, this study suggests that researchers cannot effectively judge the influence of a program by looking at beliefs at the end of the teacher education program because teachers continue to learn from their experiences in their program while they teach.

Implications for Mathematics Educators

The participants in this study needed time in the classroom to experience the ineffectiveness of traditional teaching practices in which they believed at the start of their teacher education programs. After the teachers had personal teaching experiences, they were able to reflect on their past experiences in light of what they learned in their teacher education program. I suggest that beginning teachers need to be given the support throughout their induction years to reflect on what they learned. Beginning teachers need assistance through their first years of teaching to build confidence in their abilities and to reflect on their beliefs. Therefore, mathematics teacher educators should continue to focus on teachers' belief changes after the teachers complete their teacher education programs.

Implications for Policy Makers

Much debate has centered on the effectiveness of teacher education programs and whether alternate certification programs such as Teach for America could be more effective (Ballou & Podgursky, 2000; Darling-Hammond, Holtzman, Gatlin, & Heilig, 2005). The debate has gone as far as the Secretary of Education arguing for the restructuring of teacher certification systems to de-emphasize education training and to make student teaching and education coursework optional (U.S. Department of Education, 2002). Because of these views, Darling-Hammond et al. (2005) explained, "The policy implications of these debates are far-reaching, affecting teacher education and certification policies as well as policies regarding school funding and educational rights" (p. 2).

However, there are few longitudinal studies of teacher education programs or of alternative certification programs to provide evidence to demonstrate to policy makers how influential these programs can be for teachers. This study provided evidence that teacher education programs can have a long-term impact on their graduates. Additional studies of this nature, of both standard and alternative certification programs, are warranted before decisions are made about eliminating particular aspects of teacher education programs. The question remains as to whether the longitudinal effects seen from my participants' teacher education programs could be replicated with other certification programs. Also, the long-term effectiveness of alternative certification programs could be difficult to determine due to the high turnover rate (Benner, 2000). Therefore, policy makers should become aware of the longitudinal effects of these programs and the influences they have on future teachers before making the far-reaching decisions to which Darling-Hammond referred.

Implications for Exploration of Mathematical Beliefs

The participants in this study demonstrated that individuals' more general beliefs about teaching and learning could also influence mathematics-specific beliefs and teaching practices for elementary mathematics teachers, which is consistent with Pajares' (1992) claim that beliefs help individuals define and understand their worlds and themselves. This result suggests that mathematics teacher educators should help preservice elementary mathematics teachers become aware of their general beliefs about teaching and learning so that they can look for connections or disconnections with their beliefs about mathematics teaching and learning. Having preservice teachers reflect on previous experiences from their personal lives as well as their past schooling experiences could help them articulate their beliefs about the nature of mathematics, teaching mathematics, and learning mathematics.

For mathematics education researchers, this study provides evidence of the importance of broadening our theoretical lens from investigating only mathematical beliefs to investigating more general beliefs. Researchers need to investigate a variety of aspects of individuals' teaching and learning experiences as well as their lives outside of the teaching profession to explore how individuals construct their mathematical beliefs. Cross (2009) stated, “[beliefs] are considered to be very influential in determining how individuals frame problems and structure tasks and are thought to be strong predictors of human behavior” (p. 326). Thus, to understand elementary teachers’ mathematics-specific beliefs, researchers need to investigate teachers’ general beliefs.

Implications for Professional Developers

This study revealed that economic issues caused the teachers to change their teaching practices. The educational and economic landscape changed drastically across the last 10 years, and the recession caused the student population of many schools to rapidly alter and caused the teachers to change their teaching practices to accommodate these students’ needs. Professional developers and district administrators should be aware of the potential influences of future economic events and be ready to provide support to teachers as they deal with changing student needs.

Implications for Researchers

My participants had to rely on their memory of past events to determine what they found to be influential to their beliefs. The focus group meeting provided the teachers with the opportunity to reminisce about shared experiences and to refresh their memories about other past experiences. The focus group setting also provided a forum for them to describe what they found to be most influential, and it provided them the opportunity to agree or disagree with others’ assertions.

Researchers investigating the long-term influence of different activities should consider using focus groups to help validate what individuals report. When teachers reminisce about past experiences in a supportive, open environment, they are able to consider other views that support and refute their claims. This investigation provides evidence to show that focus group discussion can support determining the long-term influences of events in individuals' lives.

Future Research

From this investigation, future research could develop in many ways. Further longitudinal studies on beliefs could explore what shapes beliefs over time. Further studies into teacher education programs could explore what practices implemented in the programs could have a long-term influence on teachers' beliefs. Future research could be conducted into whether general beliefs about teaching and learning have the same influence on secondary mathematics teachers' beliefs or elementary teachers' beliefs in other content areas, such as science or social studies. Finally, further investigation into how the recession impacted teaching practices could be explored.

Because most of the existing research on belief change covers a relatively short span of time (often only a semester), more long-term studies are needed to investigate the effects of teacher education programs on beliefs. Longitudinal studies that collect data on teachers at regular intervals after they enter the profession would be particularly useful for pinpointing influences on beliefs. Research has shown that teacher effectiveness typically increases markedly after about the second year of teaching (Hanushek, Kain, & Rivkin, 1998); thus studies investigating belief change occurring from the teacher education program need to extend their exploration past the teacher's second year of teaching.

Future research is needed to explore what specific practices (specific readings, activities, field experiences, mathematical tasks) implemented in teacher education programs have a long-term, sustainable influence on teachers' beliefs and practices. An investigation into what activities matter to teachers years after they finish their teacher education program, as well as what, specifically, the teachers took away from these activities, would be useful in making changes to teacher education programs.

Lastly, future research should be conducted to see if the recession influenced other teachers and in what ways. Such studies might look at teachers in different settings, such as rural and urban, teachers of different ages of students, such as middle and high school, and teachers in different areas of the country where the recession was felt more and less acutely. When future economic events occur, researchers should be poised to investigate their effects on teachers, and professional developers could use this information to plan for changes in teaching practices as a result of economic change.

Concluding Remarks

The three teachers in my study were followed for over 12 years of their careers, from preservice teachers to experienced teachers, and I was able to determine much about their construction of beliefs. The teachers had their own unique development over time. These teachers experienced various factors that influenced their teaching and beliefs, but what I can say over all is that life changes individuals. When preservice teachers first start their teacher education program, they only have their past schooling experience to compare to what they are learning. After they become educators and experience changes in their lives, they take new meaning from experiences from their past and use these reinterpretations of past experience to better their futures.

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APPENDIX A

Interview #1 Protocol

I would like to start by thanking you for taking time out of your busy schedule to speak with me. I am currently researching the beliefs and practices of a practicing elementary mathematics educator and to determine what has influenced these current beliefs about the nature of mathematics, teaching mathematics, and learning mathematics, as well as discover other influences affecting their change in beliefs over time. I am trying to better understand the factors that lead to a belief change in teachers. Your insight is very valuable to help in this discovery.

Before we start, I wanted to quickly remind you the interviews will be audio-taped. No individually identifiable information about you will be shared with others. I will be assigned a pseudonym that will be used in transcripts and any publications and/or presentations that result from this study. Feel free to skip any questions you do not want to answer and at any time you may end the interview. I anticipate that the interview will take about an hour. Though I will be asking you questions, if at any time you have questions throughout the interview, please feel free to ask. Do you have any questions before we begin?

I would like to start the interview by learning a little about:

1. I would like for you to complete the sentence: Learning mathematics is like:

working on an assembly line	watching a movie
cooking with a recipe	picking fruit from a tree
working a jigsaw puzzle	conducting an experiment
building a house	creating a clay sculpture
	Other ____________________

Which of the above similes best describes learning mathematics? Why?

2. I would like for you to complete the sentence: A mathematics teacher is like a:

news broadcaster	entertainer
doctor	orchestra conductor
gardener	coach
missionary	social worker
	Other__________________

Which of the above similes best describes mathematics teaching? Why?

3. Read the following word problems:

Manipulatives or Tools Available: Grid paper, interlocking cubes

1. The kindergarten class is coming to watch a play in our classroom. There are 20 students. In what different ways could we arrange the chairs for them so that all the rows are equal?
2. The two third-grade classes are going to watch our play in the cafeteria. There are 49 students altogether. In what different ways would we arrange the chairs for them so that all the rows are equal?
3. What do you notice about your solutions for problem 1 and problem 2?

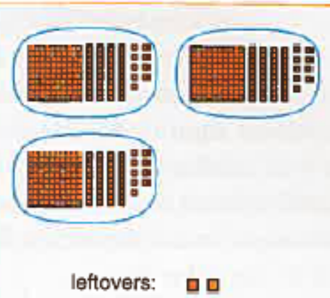
From *Investigations in Number, Data, and Space, Grade 4,* by Cornelia Tierney, Mark Ogonowski, Andee Rubin, and Susan Jo Russell, p. 75. Menlo Park, Calif.: Dale Seymour, 1998.

   a) How would you use this task in a class?
   b) When would you use this task during a unit of instruction?

4. How important is it for a student to know their basic mathematics facts?
   a) How do you assess if students understand their basic facts?
   b) Do you ever use timed practice of basic facts*?*
   Probing Question: If you do, when do you implement these tasks? If not, what are your views of timed basic fact activities?

5. Please watch the following videos, and focus on the teacher's actions:
   a) What is your view of this teacher's role in her classroom?
   Probing Question: What did she do well in her classroom? What would you change?
   b) How would you teach this lesson in your classroom?
   Probing Question: Would you teach the lesson differently?

6. Read through the following student solutions to the problem 449 divided by 3:

Maria	Tony	Lakisha	Ashley
	3)449 −300 100 149 −120 40 29 −27 9 2 149	149r2 9 40 100 3)449 −300 149 −120 29 −27 2	149r2 3)449 −3 149 −12 29 −27 2

From *Learning Mathematics in Elementary and Middle Schools,* by W. George Cathcart, Yvonne Pothier, James Vance, and Nadine Bezuk, p. 198. Boston, MA: Pearson Education, 2011.

a) Do these solutions make sense?
b) If you were their teacher, which of the approaches would you like to see children share?
c) Consider just the strategies on which you would focus in a unit on division of whole numbers. Over a several-weeks unit, in which order would you focus on these strategies?

7. Please watch the following two videos of students solving addition problems

George's IMAP 1 movie 104 and
Stacy's IMAP 1 movie 200.

a) Which child shows the greater mathematical understanding? Why?
b) Of 10 students, how many do you think would choose Stacy's approach? Why?
c) If 10 students used Stacy's approach, how many do you think would be successful in solving the problem 34+57? Why?
d) Of 10 students, how many do you think would choose George's approach? Why?
e) If 10 students used George's approach, how many do you think would be successful in solving the problem 120+96? Why?
f) If you were the teacher, which approach would you prefer that your students use? Why?

8. Is there anything else that you would like to share that I didn't ask you?

Transition: Thank you so much for your time. Your insight is very valuable to my study.

APPENDIX B

Interview #2 Protocol

NOTE: This survey changed for each participant depending on her responses to the KFABC survey.

I would like to start by thanking you again for taking time out of your busy schedule to speak with me. Today I am going to ask you some questions about what influenced your belief development.

Before we start, I wanted to quickly remind again that the interviews will be audio-taped. No individually identifiable information about you will be shared with others. I will be assigned a pseudonym that will be used in transcripts and any publications and/or presentations that result from this study. Feel free to skip any questions you do not want to answer and at any time you may end the interview. I anticipate that the interview will take about an hour. Though I will be asking you questions, if at any time you have questions throughout the interview, please feel free to ask. Do you have any questions before we begin?

I would like to start the interview by ask:

1. Can you describe a time when something happened that changed what you thought about teaching or learning?
   Probing questions: What was your initial view? What changed after this happened? Can you remember any other times?

2. In your KFABC Survey, you stated that your father was a big influence in your life. Could you describe what kind of teacher your father was?
   Probing questions: How did this affect the way you wanted to be a teacher?

3. Also in the survey, you said that your previous teachers had a large impact on your teaching style. Could you name a specific teacher and describe him/her to me?
   Probing questions: Can you describe an event in which she was involved that made you like her so much? Could you name and describe a specific teacher that had a negative influence in your life? Could you describe that event?

4. In the survey you stated that your mathematics education courses were not taught like any other mathematics course. How did this affect your teaching practice?

5. In your survey, you also said that previous professional development classes made a difference. Could you describe those classes?

Probing questions: What did you do in the PD? How do you use the information given during those PD in your class?

6. Was there an experience teaching mathematics in elementary school that really made a difference in your educational development?

Transition: Now that I have some of your responses on the influences on your view of mathematics, I would like to ask you about the survey and the observation.

1. From taking the KFAB survey, were there any answers to questions you would like to elaborate on?

2. Are there any aspects of the classroom observation you would like to discuss?

3. Is there anything else that you would like to share that I didn't ask you?

Transition: Thank you so much for your time. Your insight is very valuable to my study.

APPENDIX C

Interview #3 Protocol

Note: This interview was conducted after all three classroom observations and two interviews. I gave the teacher a copy of my interpretation of her beliefs constructed from a preliminary analysis of the data.

Today, we will be conducting our final interview for this study. Again, I would like to start by thanking you for taking time out of your busy schedule to speak with me. Before we start, I wanted to quickly remind you the interview will be audio-taped. No individually identifiable information about you will be shared with others. I will be assigned a pseudonym that will be used in transcripts and any publications and/or presentations that result from this study. Feel free to skip any questions you do not want to answer and at any time you may end the interview. I anticipate that the interview will take about an hour. Though I will be asking you questions, if at any time you have questions throughout the interview, please feel free to ask. Do you have any questions before we begin?

I would like to start the interview by ask:

1. What was your first impression of the document I sent you?
    a. *Probing questions: Why did you feel that way? What areas did you like or dislike the most?*

2. Let us go through the document together to determine what you agree and disagree with in the description.
    a. To what extent do you agree or disagree with the interpretation of your beliefs about the nature of mathematics?
    b. To what extent do you agree or disagree with the interpretation of your beliefs about the teaching of mathematics?
    c. To what extent do you agree or disagree with the interpretation of your beliefs about the learning of mathematics?

3. Tell me how your beliefs about the nature of mathematics can be seen in your teaching practices.
    a. *Probing Questions: What about your beliefs about teaching or learning?*

4. Is there anything you would like to add that was not written in the document?

5. Which of the three statements best describes your views about the nature of mathematics when you began your teacher education program?
    a. Mathematics is a set of rules and procedures.

   b. Mathematics is a unified, unchanging body of knowledge.
   c. Mathematics is a man-made creation that is continually expanding.

6. Which of the three statements best describes your views about the mathematics teacher's role when you began your teacher education program?
   a. The teacher's role is to tell the students how to implement procedures and to make sure the student understand the basic skills.
   b. The teacher's role is to explain mathematical concepts and develop students' conceptual understanding of set mathematical concepts.
   c. The teacher's role is to facilitate students' problem solving by teaching students to reason mathematically.

7. Which of the three statements best describes your views about student's learning mathematics when you began your teacher education program?
   a. Students can passively receive knowledge to learn mathematics.
   b. Students need to actively engage with knowledge to learn mathematics.

8. Do you have any future plans to enhance your mathematics education knowledge?

9. Is there any other information you would like to add?

APPENDIX D

Focus Group Interview Protocol

Good morning and welcome to our session. Thanks for taking the time to join us to talk today. I have finished going through all your data, and I want to ask you about some of the similarities that I found.

There are no wrong answers but rather differing points of view. Please feel free to share your point of view even if it differs from what others have said. Keep in mind that we're just as interested in negative comments as positive comments, and at times the negative comments are the most helpful.

You've probably noticed the microphone. We're tape recording the session because we don't want to miss any of your comments. People often say very helpful things in these discussions and we can't write fast enough to get them all down. We will be on a first name basis tonight, and we won't use any names in our reports. You may be assured of complete confidentiality.

Well, let's begin. First item that you all identified as being an influential to your beliefs was Dr. Mathis's methods courses.

1. Could you describe an event in your mathematics education program you found to have the most influence on your view of mathematics?
   Probing questions: Could you describe an event that influenced your view of teaching mathematics? What about learning mathematics?

You also identified your math content courses as influentially.

2. What was influential about the course?
3. Do you think you got the same things out of the class now as you did when you first took the courses?

You also identified that you were good at mathematics some of you identified that you loved the subject before you started teaching.

4. How did the love of mathematics influence the way you teach?
5. Also, you all identified that you were very self-motivated persons throughout your lives. How has that influence you being a teacher today?
6. How about your self-confidence? When you first started teaching did you always have the same self-confidence in what you were doing?

During these 10 years, all of you were married and had children during that time.

7. How has these experiences influenced you mathematically?

Also, you all identified that making mathematics FUN was important.

8. Why do you believe it is true across everyone?
9. How did your view of fun change since your first year of teaching?

When Jayne and I were discussing changes, she identified the recession as influencing her teaching. Would you like to describe your theory?

10. How did you feel that it influenced your students?

When I asked whom you would go to if you had a question about your teaching, you each identified a fellow coworker. Also, you identified other coworkers as influencing the way you view mathematics.

11. What do you think are all the different ways coworkers affect your teaching?

In your interviews, you addressed a few events in your past that might have shaped your thinking.

12. Everyone identified _________ as being an important factor affecting their beliefs. Why do you believe this is true?
    Probing questions: How did this affect the way you wanted to be a teacher?
    - Standards
    - Textbooks
    - Technology
    - PD
    - Second degree
    - ESOL

13. Out of everything we have discussed today, which one did you feel had the largest influence and why?

14. Is there anything else that you would like to share that I didn't ask you?

Transition: Thank you so much for your time. Your insight is very valuable to my study.

APPENDIX E

Participants' Mathematical Quality of Instruction Scores

Laura's MQI Scores for Observation 1

Class Section	1	2	3	4	5	6	7
Classroom Work is Connected to Mathematics							
0 = No, 1 = Yes	1	1	1	1	1	1	1
Richness of the Mathematics							
Linking and Connections	1	2	2	2	2	2	1
Explanations	1	3	3	2	3	3	2
Multiple Procedures or Solution Methods	1	2	1	1	3	3	3
Developing Mathematical Generalizations	1	2	2	1	1	1	1
Mathematical Language	1	2	1	2	2	1	1
Overall Richness of the Mathematics	1	3	2	3	3	3	3
Working with Students and Mathematics							
Remediation of Student Errors and Difficulties	1	1	1	2	1	2	1
Responding to Student Mathematical Productions in Instruction	1	2	3	2	3	3	2
Overall Working with Students and Mathematics	1	2	2	2	3	2	2
Errors and Imprecision							
Major Mathematical Errors	1	1	1	1	1	1	1
Imprecision in Language or Notation (Mathematical Symbols)	1	1	1	1	1	1	1
Lack of Clarity	1	1	1	1	1	1	1
Overall Errors and Imprecision	1	1	1	1	1	1	1
Student Participation in Meaning-Making and Reasoning							
Students Provide Explanations	1	2	3	2	3	3	3
Student Mathematical Questioning and Reasoning	1	2	3	1	1	2	1
Enacted Task Cognitive Activation	1	2	2	3	1	2	2
Overall Student Participation in Meaning-Making and Reasoning	1	2	3	3	3	2	3
						Overall Lesson	2
						Overall MKT	3

Laura's MQI Scores for Observation 2

Class Section	1	2	3	4	5	6	7	8
Classroom Work is Connected to Mathematics								
0 = No, 1 = Yes	1	1	1	1	1	1	1	1
Richness of the Mathematics								
Linking and Connections	2	2	2	2	2	2	2	2
Explanations	3	3	2	3	3	3	3	3
Multiple Procedures or Solution Methods	1	3	1	2	1	2	2	2
Developing Mathematical Generalizations	1	1	1	1	1	1	1	1
Mathematical Language	2	1	2	2	2	2	2	2
Overall Richness of the Mathematics	2	3	2	3	3	2	2	2
Working with Students and Mathematics								
Remediation of Student Errors and Difficulties	2	2	2	3	2	3	3	3
Responding to Student Mathematical Productions in Instruction	1	2	2	2	2	3	3	3
Overall Working with Students and Mathematics	2	2	2	2	2	3	3	3
Errors and Imprecision								
Major Mathematical Errors	1	1	1	1	1	1	1	1
Imprecision in Language or Notation (Mathematical Symbols)	1	1	1	1	1	1	1	1
Lack of Clarity	1	1	1	1	1	1	1	1
Overall Errors and Imprecision	1	1	1	1	1	1	1	1
Student Participation in Meaning-Making and Reasoning								
Students Provide Explanations	3	3	3	3	3	3	3	3
Student Mathematical Questioning and Reasoning	2	1	1	1	2	3	2	2
Enacted Task Cognitive Activation	1	2	1	1	1	2	2	2
Overall Student Participation in Meaning-Making and Reasoning	3	3	2	2	3	3	3	3
							Overall Lesson	2
							Overall MKT	3

Laura's MQI Scores for Observation 3

Class Section	1	2	3	4	5	6	7	8	9	10
Classroom Work is Connected to Mathematics										
0 = No, 1 = Yes	1	1	1	0	0	1	1	1	1	1
Richness of the Mathematics										
Linking and Connections	2	2	2	1	1	1	2	2	2	2
Explanations	3	3	2	1	1	3	3	3	3	2
Multiple Procedures or Solution Methods	2	1	1	1	1	2	1	1	2	1
Developing Mathematical Generalizations	2	2	1	1	1	1	2	2	2	2
Mathematical Language	2	2	3	2	2	2	2	3	3	2
Overall Richness of the Mathematics	2	2	2	1	1	2	2	3	3	2
Working with Students and Mathematics										
Remediation of Student Errors and Difficulties	1	2	1	1	1	2	3	2	2	2
Responding to Student Mathematical Productions in Instruction	2	3	1	1	1	2	3	3	3	2
Overall Working with Students and Mathematics	2	3	1	1	1	2	3	3	3	2
Errors and Imprecision										
Major Mathematical Errors	1	1	1	1	1	1	1	1	1	1
Imprecision in Language or Notation (Mathematical Symbols)	1	1	1	1	1	1	1	1	1	1
Lack of Clarity	1	1	1	1	1	1	1	1	1	1
Overall Errors and Imprecision	1	1	1	1	1	1	1	1	1	1
Student Participation in Meaning-Making and Reasoning										
Students Provide Explanations	3	3	1	1	1	1	3	3	3	2
Student Mathematical Questioning and Reasoning	2	3	1	1	1	1	2	3	3	1
Enacted Task Cognitive Activation	2	2	1	1	1	2	2	2	2	1
Overall Student Participation in Meaning-Making and Reasoning	3	3	1	1	1	1	3	3	3	2
									Overall Lesson	2
									Overall MKT	3

Jayne's MQI Scores for Observation 1

Class Section	1	2	3	4	5	6
Classroom Work is Connected to Mathematics						
0 = No, 1 = Yes	1	1	1	1	1	1
Richness of the Mathematics						
Linking and Connections	2	1	2	1	3	3
Explanations	3	2	2	2	2	2
Multiple Procedures or Solution Methods	2	1	1	1	2	2
Developing Mathematical Generalizations	1	1	1	1	2	1
Mathematical Language	2	2	2	2	1	2
Overall Richness of the Mathematics	3	2	2	2	3	2
Working with Students and Mathematics						
Remediation of Student Errors and Difficulties	2	2	2	2	2	3
Responding to Student Mathematical Productions in Instruction	3	3	1	2	2	2
Overall Working with Students and Mathematics	3	3	2	2	2	3
Errors and Imprecision						
Major Mathematical Errors	1	1	1	1	1	1
Imprecision in Language or Notation (Mathematical Symbols)	1	1	1	1	1	1
Lack of Clarity	1	1	1	1	1	1
Overall Errors and Imprecision	1	1	1	1	1	1
Student Participation in Meaning-Making and Reasoning						
Students Provide Explanations	3	2	1	2	2	3
Student Mathematical Questioning and Reasoning	1	1	1	1	2	2
Enacted Task Cognitive Activation	3	1	1	3	3	3
Overall Student Participation in Meaning-Making and Reasoning	3	2	1	3	3	3
					Overall Lesson	3
					Overall MKT	3

Jayne's MQI for Observation 2

Class Section	1	2	3	4	5
Classroom Work is Connected to Mathematics					
0 = No, 1 = Yes	1	1	1	1	1
Richness of the Mathematics					
Linking and Connections	3	3	3	3	2
Explanations	3	2	3	3	3
Multiple Procedures or Solution Methods	1	1	1	1	1
Developing Mathematical Generalizations	1	1	1	1	1
Mathematical Language	2	1	2	2	2
Overall Richness of the Mathematics	3	3	3	3	2
Working with Students and Mathematics					
Remediation of Student Errors and Difficulties	2	1	2	3	3
Responding to Student Mathematical Productions in Instruction	2	1	2	3	3
Overall Working with Students and Mathematics	2	1	2	3	3
Errors and Imprecision					
Major Mathematical Errors	1	1	1	1	1
Imprecision in Language or Notation (Mathematical Symbols)	1	1	1	1	1
Lack of Clarity	1	1	1	1	1
Overall Errors and Imprecision	1	1	1	1	1
Student Participation in Meaning-Making and Reasoning					
Students Provide Explanations	2	2	3	3	3
Student Mathematical Questioning and Reasoning	1	1	1	1	1
Enacted Task Cognitive Activation	1	1	3	3	3
Overall Student Participation in Meaning-Making and Reasoning	2	2	3	3	3
				Overall Lesson	3
				Overall MKT	3

Jayne's MQI Scores for Observation 3

Class Section	1	2	3	4	5
Classroom Work is Connected to Mathematics					
0 = No, 1 = Yes	1	1	1	1	1
Richness of the Mathematics					
Linking and Connections	1	1	1	1	1
Explanations	3	3	3	3	3
Multiple Procedures or Solution Methods	2	2	2	2	2
Developing Mathematical Generalizations	1	2	1	1	1
Mathematical Language	2	2	2	2	2
Overall Richness of the Mathematics	3	2	3	3	3
Working with Students and Mathematics					
Remediation of Student Errors and Difficulties	3	1	2	2	2
Responding to Student Mathematical Productions in Instruction	3	1	3	3	3
Overall Working with Students and Mathematics	3	1	3	3	3
Errors and Imprecision					
Major Mathematical Errors	1	1	1	1	1
Imprecision in Language or Notation (Mathematical Symbols)	1	1	1	1	1
Lack of Clarity	1	1	1	1	1
Overall Errors and Imprecision	1	1	1	1	1
Student Participation in Meaning-Making and Reasoning					
Students Provide Explanations	2	1	2	3	3
Student Mathematical Questioning and Reasoning	1	1	2	3	3
Enacted Task Cognitive Activation	1	1	3	3	3
Overall Student Participation in Meaning-Making and Reasoning	2	1	2	3	3
				Overall Lesson	2
				Overall MKT	3

Jennifer's MQI Scores for Observation 1

Class Section	1	2	3	4	5	6	7	8	9
Classroom Work is Connected to Mathematics									
0 = No, 1 = Yes	1	1	1	1	1	1	1	1	1
Richness of the Mathematics									
Linking and Connections	1	2	2	1	1	2	2	2	3
Explanations	3	3	2	2	3	3	3	2	3
Multiple Procedures or Solution Methods	3	1	1	1	1	1	1	1	2
Developing Mathematical Generalizations	1	1	1	1	1	1	1	1	1
Mathematical Language	2	2	2	1	2	2	2	2	2
Overall Richness of the Mathematics	3	3	1	2	1	3	3	3	3
Working with Students and Mathematics									
Remediation of Student Errors and Difficulties	2	3	1	2	1	3	3	2	1
Responding to Student Mathematical Productions in Instruction	2	2	1	2	1	2	2	2	2
Overall Working with Students and Mathematics	2	3	1	2	1	3	3	2	2
Errors and Imprecision									
Major Mathematical Errors	1	1	1	1	1	1	1	1	1
Imprecision in Language or Notation (Mathematical Symbols)	1	1	1	1	1	1	1	1	1
Lack of Clarity	1	1	1	1	1	1	1	1	1
Overall Errors and Imprecision	1	1	1	1	1	1	1	1	1
Student Participation in Meaning-Making and Reasoning									
Students Provide Explanations	3	2	3	3	3	3	3	3	3
Student Mathematical Questioning and Reasoning	2	2	2	3	3	3	3	3	2
Enacted Task Cognitive Activation	2	1	3	3	3	3	3	3	1
Overall Student Participation in Meaning-Making and Reasoning	3	2	3	3	3	3	3	3	3
								Overall Lesson	3
								Overall MKT	3

Jennifer's MQI Scores for Observation 2

Class Section	1	2	3	4	5	6	7	8	9
Classroom Work is Connected to Mathematics									
0 = No, 1 = Yes	1	1	1	1	0	1	1	1	1
Richness of the Mathematics									
Linking and Connections	1	2	2	2	1	1	1	1	2
Explanations	2	3	3	3	1	3	2	2	3
Multiple Procedures or Solution Methods	1	1	2	2	1	1	1	1	2
Developing Mathematical Generalizations	1	1	1	1	1	1	1	1	1
Mathematical Language	2	2	2	2	2	2	2	2	2
Overall Richness of the Mathematics	2	3	2	3	1	3	2	2	2
Working with Students and Mathematics									
Remediation of Student Errors and Difficulties	2	3	2	3	1	2	2	2	2
Responding to Student Mathematical Productions in Instruction	2	3	3	3	1	1	2	2	2
Overall Working with Students and Mathematics	2	3	3	3	1	1	2	2	2
Errors and Imprecision									
Major Mathematical Errors	1	1	1	1	1	1	1	1	1
Imprecision in Language or Notation (Mathematical Symbols)	1	1	1	1	1	1	1	1	1
Lack of Clarity	1	1	1	1	1	1	1	1	1
Overall Errors and Imprecision	1	1	1	1	1	1	1	1	1
Student Participation in Meaning-Making and Reasoning									
Students Provide Explanations	2	3	2	2	1	2	2	2	3
Student Mathematical Questioning and Reasoning	1	2	2	1	1	1	2	3	2
Enacted Task Cognitive Activation	2	1	1	1	1	1	2	3	3
Overall Student Participation in Meaning-Making and Reasoning	2	3	2	2	1	1	2	3	3
								Overall Lesson	3
								Overall MKT	3

Jennifer's MQI Scores for Observation 3

Class Section	1	2	3	4	5	6	7	8	9	10
Classroom Work is Connected to Mathematics										
0 = No, 1 = Yes	1	1	1	1	1	1	1	1	1	1
Richness of the Mathematics										
Linking and Connections	2	3	1	1	1	2	2	1	2	2
Explanations	3	2	3	3	3	3	3	3	3	2
Multiple Procedures or Solution Methods	2	1	1	2	2	1	1	1	2	2
Developing Mathematical Generalizations	1	1	1	1	1	1	1	1	1	2
Mathematical Language	2	2	2	2	2	2	2	2	2	2
Overall Richness of the Mathematics	2	3	2	3	3	3	3	2	3	2
Working with Students and Mathematics										
Remediation of Student Errors and Difficulties	3	2	3	2	3	3	3	2	3	2
Responding to Student Mathematical Productions in Instruction	3	3	3	2	3	3	3	2	3	2
Overall Working with Students and Mathematics	3	3	3	2	3	3	3	2	3	2
Errors and Imprecision										
Major Mathematical Errors	1	1	1	1	1	1	1	1	1	1
Imprecision in Language or Notation (Mathematical Symbols)	1	1	1	1	1	1	1	1	1	1
Lack of Clarity	1	1	1	1	1	1	1	1	1	1
Overall Errors and Imprecision	1	1	1	1	1	1	1	1	1	1
Student Participation in Meaning-Making and Reasoning										
Students Provide Explanations	2	3	3	3	3	2	3	3	3	3
Student Mathematical Questioning and Reasoning	2	3	3	2	2	3	3	3	3	1
Enacted Task Cognitive Activation	3	2	1	1	1	3	3	1	2	1
Overall Student Participation in Meaning-Making and Reasoning	2	3	3	3	3	3	3	3	3	2
									Overall Lesson	3
									Overall MKT	3

APPENDIX F

Known Factors Affecting Belief Change Survey

Directions*: Please fill out this survey to the best of your ability either with pen or by typing in your responses. It will take less than one hour to complete. If the question does not apply to you or if you do not want to answer, you are welcome to leave the space bank or write in N/A. If you have any questions, you are welcome to contact me at asawyer@uga.edu. Thank you for your help in studying this phenomenon.*

Personal Experiences:

1. When you were in school, to whom did you go for help in mathematics?

   ____

   a. How did they help you?

   ____

   ____

   ____

   ____

   b. When you got older, did someone different help you in mathematics? (YES/NO)

   c. How did this new individual help you?

   ____

   ____

   ____

   ____

2. Do you ever talk about mathematics outside of the classroom in which you teach?

   (YES/NO)

a. Please list some individuals with whom you discuss mathematics.

____

b. What do you discuss?

____

____

____

____

3. Have you regularly helped any children other than your students with mathematics? *(YES/NO)*

   a. If so, how old were they?

   ____

   b. If so, how did you help them learn mathematics?

   ____

   ____

   ____

   ____

4. Were there individual(s) outside of school who negatively influenced you mathematically? (YES/NO)

   a. How did they influence you?

   ____

   ____

5. Were there individual(s) outside of school who positively influenced you mathematically? (YES/NO)
    a. How did they influence you?

School Experiences:

6. During your past schooling, did you have teachers who negatively influenced you mathematically?

    a. When did you have those teachers?

    b. What about those experiences was negative?

7. During your past schooling, did you have teachers who positively influenced you mathematically?

a. When did you have these teachers?

____

b. What about those experiences was positive?

____

____

____

____

8. Did any classmates during your K-16 education influence you mathematically? (YES/NO)

   a. How did they influence you?

____

____

____

____

Teacher Education Experience:

9. Did your mathematics experience during your teacher education program at the University of Georgia affect your teaching? (YES/NO)

   a. If so, how did your teacher education program affect your teaching?

____

____

____

____

10. Have you taken any university mathematics content courses since you graduated? (YES/NO)

    a. If so, what did you take?

    ____

    b. If so, what did you learn?

    ____

    ____

    ____

    ____

11. Have you taken any university mathematics pedagogy (methods) courses since you graduated? *(YES/NO)*

    a. If so, what course?

    ____

    b. If so, what did you learn?

    ____

    ____

    ____

    ____

12. What kinds of professional development (PD) in mathematics have you taken?

    ____

    a. Describe a PD experience that influenced your mathematics teaching.

    ____

    ____

Teaching Experience:

13. How have your students influenced the way you view how people learn mathematics?

14. Name the different mathematical textbooks you have taught from:

    a. Which types of textbook(s) did you like and why?

    b. Which textbook(s) did you dislike and why?

15. How many schools have you taught at?

a. If you taught at more than one school, why did you change schools?

b. What about each school did you enjoy?

c. What about each school did you not enjoy?

16. What grade levels have you taught?

a. What about each grade level did you enjoy?

b. What about each grade level did you not enjoy?

____

____

____

____

17. Please describe the student populations from your schools.

____

____

a. How did you teach differently depending on the student population?

____

____

____

____

18. Did your school administration affect the way you teach? *(YES/NO)*

a. If so, how did it affect your teaching?

____

____

19. How has standardized testing affected your teaching of mathematics?

____

____

____

____

20. Has any technology influenced your mathematics teaching?

APPENDIX G

IMAP Belief Scores

Laura 2001

Beliefs about		Segment Scores			Permutation	Belief Score
Nature of Math	B1	S3.2 1	S3.3 1		(1,1)	1
Learning Math	B2	S3 1	S4 0	S8 0	(1, 0, 0)	0
	B3	S4 1	S9 2		(1, 2)	2
	B4	S3.3 3	S9 2		(3,2)	3
Teaching Math	B5	S2 N/A	S5 3	S7 1	(N/A, 3, 1)	2
	B6	S2 N/A	S8 1	S9 0	(N/A, 1, 0)	1
	B7	S5 1	S7 1		(1, 1)	0

Laura 2013

Beliefs about		Segment Scores			Permutation	Belief Score
Nature of Math	B1	S3.2 3	S3.3 2		(3,2)	3
Learning Math	B2	S3 3	S4 1	S8 2	(3, 1, 2)	3
	B3	S4 3	S9 N/A		(3, N/A)	3
	B4	S3.3 4	S9 N/A		(4, N/A)	2 or 3
Teaching Math	B5	S2 3	S5 3	S7 N/A	(3, 3, N/A)	3 or 4
	B6	S2 3	S8 0	S9 N/A	(3, 0, N/A)	2 or 3
	B7	S5 3	S7 N/A		(3, N/A)	2 or 3

Jayne 2001

Beliefs about		Segment Scores			Permutation	Belief Score
Nature of Math	B1	S3.2 1	S3.3 1		(1,1)	1
Learning Math	B2	S3 1	S4 2	S8 2	(1, 2, 2)	3
	B3	S4 1	S9 0		(1, 0)	0
	B4	S3.3 2	S9 2		(2,2)	2
Teaching Math	B5	S2 N/A	S5 1	S7 1	(N/A, 1, 1)	1
	B6	S2 N/A	S8 1	S9 0	(N/A, 1, 0)	1
	B7	S5 1	S7 3		(1, 3)	2

Jayne 2013

Beliefs about		Segment Scores			Permutation	Belief Score
Nature of Math	B1	S3.2 3	S3.3 N/A		(3, N/A)	2 or 3
Learning Math	B2	S3 N/A	S4 1	S8 2	(N/A, 1, 2)	2 or 3
	B3	S4 1	S9 3		(1, 3)	2
	B4	S3.3 N/A	S9 3		(N/A, 3)	2 or 3
Teaching Math	B5	S2 3	S5 1	S7 2	(3, 1, 2)	3
	B6	S2 3	S8 2	S9 1	(3, 2, 1)	4
	B7	S5 3	S7 3		(3, 3)	3

Jennifer 2001

Beliefs About		Segment Scores			Permutation	Belief Score
Nature of Math	B1	S3.2 1	S3.3 0		(1, 0)	0
Learning Math	B2	S3 0	S4 0	S8 2	(0, 0, 2)	1
	B3	S4 1	S9 2		(1, 2)	2
	B4	S3.3 2	S9 1		(2, 1)	1
Teaching Math	B5	S2 N/A	S5 2	S7 1	(N/A, 2, 1)	2
	B6	S2 N/A	S8 0	S9 0	(N/A, 0, 0)	0
	B7	S5 2	S7 2		(2, 2)	2

Jennifer 2013

Beliefs About		Segment Scores			Permutation	Belief Score
Nature of Math	B1	S3.2 2	S3.3 2		(2, 2)	3
Learning Math	B2	S3 2	S4 0	S8 2	(2, 0, 2)	2
	B3	S4 1	S9 3		(1, 3)	2
	B4	S3.3 4	S9 3		(4, 3)	3
Teaching Math	B5	S2 3	S5 3	S7 1	(3, 3, 1)	3
	B6	S2 2	S8 1	S9 2	(2, 1, 2)	3
	B7	S5 2	S7 2		(2, 2)	2