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Change and Relationships in Elementary Preservice Teachers' Mathematics Pedagogical
Beliefs, Teaching Efficacy Beliefs, and Content Knowledge

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Abstract

This study investigated the mathematics beliefs and content knowledge of 103 elementary preservice teachers in a developmental teacher preparation program that included a two course mathematics methods sequence. Preservice teachers' pedagogical beliefs became more cognitively-oriented during the teacher preparation program with these changes occurring during the two methods courses. Pedagogical beliefs remained stable during student teaching. The preservice teachers also significantly increased their personal efficacy for teaching mathematics throughout the program with these shifts occurring across both methods courses and into student teaching. Pedagogical beliefs and teaching efficacy beliefs were not related at the beginning of the program, but, in general, were positively related throughout the program. In addition, the preservice teachers' pedagogical beliefs were positively related to their specialized content knowledge for teaching mathematics at the end of the program.

Change and Relationships in Elementary Preservice Teachers' Mathematics Pedagogical Beliefs, Teaching Efficacy Beliefs, and Content Knowledge

Introduction

In mathematics education it is not uncommon for beginning preservice teachers to come to their teacher preparation programs with a traditional view of what it means to know and do mathematics: a view of mathematics as a fixed body of knowledge to be delivered to children, usually through clear, organized presentations and lectures. In contrast, current university mathematics education programs are more likely to advocate a constructivist view of teaching and learning such as that supported by the National Council of Teachers of Mathematics (2000). For preservice teachers to be successful within a reform program, they need to do more than learn methods and materials for teaching mathematics: they need to *change* their beliefs (Richardson & Placier, 2001).

Beliefs influence teacher behavior and decision-making (Thompson, 1992; Wilson & Cooney, 2002) and change in beliefs is a crucial precursor to real change in teaching. This change is not easy. It takes time for preservice teachers to align their pedagogical beliefs with current thinking on teaching and learning mathematics and to increase their efficacy for teaching mathematics. It is a difficult process requiring thoughtful reflection and examination of teaching and learning.

But altering pedagogical beliefs and teaching efficacy beliefs is only part of preparing preservice teachers to teach mathematics. For some years now mathematicians and mathematics educators have agreed that there is a need for strong mathematical content knowledge for elementary teachers. A small number of mathematicians and many more mathematics educators propose that there is *specialized content knowledge* (SCK) needed for teaching elementary mathematics that is unique from the common mathematical content knowledge necessary to be a functioning adult (Ball, Hill, & Bass, 2005). For example, most adults could easily compute the problem $12 \div 3$. However, few would recognize that the problem can be modeled as either 4 groups of 3 or 3 groups of 4, depending on the question asked. Knowing the difference between distributive and subtractive situations in division and being able to represent those situations through real world applications is representative of the specialized knowledge needed by elementary teachers.

Prior research on preservice teachers has mostly examined mathematics pedagogical beliefs, teaching efficacy beliefs, and content knowledge as individual constructs, typically in the context of a single course (Hart, 2002; Wilkins & Brand, 2004). Of further interest is understanding changes in these constructs over time as well understanding the relationships among these constructs.

Background

A recent mandate from the Board of Regents of Georgia required an increase in the number of upper-division mathematics courses for elementary preservice teachers. Prior to the mandate, students within our program took two mathematics courses and two mathematics methods courses. In response to the directive, the program was revised to contain four mathematics courses and one methods course.

In an effort to document the impact of the change on elementary preservice teachers at Georgia State, we began a longitudinal research effort we call the Mathematics Education Research Project (MERP). The project examines how these programmatic changes influence preservice teachers' mathematics pedagogical beliefs, teaching efficacy beliefs, and specialized content knowledge for teaching mathematics. This manuscript reports results from the preservice teachers in the program prior to the mandated changes and focuses on change in beliefs and the relationships between beliefs and specialized content knowledge. This comparative group provides data for future research on the effects of the new program and some guidance on what should be emphasized in content and methods coursework.

Related Research

A review of the body of research on teachers' mathematics pedagogical beliefs, teaching efficacy beliefs, and content knowledge highlights the importance of these constructs. To lay a foundation for the research in this paper, we will examine relevant findings in each area.

Teacher Pedagogical Beliefs

Research has shown that beliefs develop over time (Richardson, 1996); that they are well-established by the time a student enters college (Pajares, 1992); and that they develop during what Lortie (1975) terms the *apprenticeship of observation* which occurs over an individual's years as a student. Elementary teacher preparation programs have a limited amount of time to impact change in preservice teacher pedagogical beliefs—usually two years or less. Impacting change in pedagogical beliefs in mathematics may be limited to one course as is evidenced by the number of studies that look at change over one course or semester. Some earlier studies did not achieve the

desired effect (Ball, 1989; Simon & Mazza, 1993), while more current studies did (Hart, 2002; Lubinski & Otto, 2004; Spielman & Lloyd, 2004; Wilkins & Brand, 2004).

While this snapshot work makes important contributions to the body of knowledge on pedagogical beliefs, it is also important to look at what happens to these beliefs over time. Vacc and Bright (1999) administered a pedagogical belief survey to 34 preservice teachers four times over a two-year period during a teacher preparation program, finding little change during the first year, but substantial change during the second year, reinforcing the need to study beliefs over time.

Teaching Efficacy Beliefs

Research establishes a robust relationship between a teacher's sense of efficacy and instructional strategies in the classroom (Riggs & Enochs, 1990) and shows that this relationship influences student achievement (Anderson, Green, & Loewen, 1988). The majority of the studies looked at *generalized* teaching efficacy, seeing it as a two-dimensional construct (Enochs, Smith, & Huinker, 2000) within Bandura's (1977) theoretical framework. The first dimension, *personal teaching efficacy*, represents a teacher's belief in his or her skills and abilities to be an effective teacher. The second dimension, *teaching outcome expectancy*, is a teacher's belief that effective teaching can bring about student learning regardless of external factors such as home environment, family background, and parental influences.

Hoy (2004) suggests that Bandura's theory implies that efficacy beliefs may be most malleable early in learning, making the first few years of teacher development critical to the long-term development of teaching efficacy. Once teaching efficacy beliefs are established, they are highly resistant to change; but studies suggest that coursework and the student teaching experience have differential impacts upon the two dimensions. Personal teaching efficacy increases during coursework and continues to increase during the student teaching experience (Hoy & Woolfolk, 1990; Plourde, 2002). However, teaching outcome expectancy beliefs increase during college coursework but decline during student teaching. This decline has been attributed to the unrealistic optimism preservice teachers have prior to student teaching about teachers' abilities to overcome negative influences (Hoy & Woolfolk, 1990).

Although there are numerous studies on generalized teaching efficacy, there has been less research specifically on the mathematics teaching efficacy of elementary preservice teachers. Those that did look at mathematics examined the effect of a single mathematics methods course and indicated significant increases in mathematics teaching efficacy upon completion of the

course (Huinker & Madison, 1997; Utley, Moseley, & Bryant, 2005).

Content Knowledge

The scholarly literature on teachers' mathematical content knowledge can be traced back for several decades. General themes are observable and contribute to what we know and do not know about elementary teachers' content knowledge and in some cases its relationship to student learning. Mewborn (2001) and Ball, Lubienski, and Mewborn (2001) provide recent summaries of research on mathematical content knowledge in the preparation and teaching practice of K-8 teachers, updating and expanding an earlier review by Fennema and Franke (1992). Mewborn identifies several themes that emerged over the last 40 years concluding that there is little correlation between the number of higher mathematics courses a teacher takes and student learning (Ball, 1990, 1991; Begle, 1972; Eisenberg, 1977), that there are certain domains within mathematics where many teachers do not have deep conceptual understandings (Post, Harel, Behr, & Lesh, 1991; Tirosh, Fischbein, Graeber, & Wilson, 1999), and that most elementary teachers in the United States do not have a deep understanding of the mathematics they teach (Bransford, Brown, & Cocking, 2001; Committee on Science and Mathematics Teacher Preparation, 2001; Mathematics Teacher Preparation Content Workshop Steering Committee, 2001).

The question as to the nature of the mathematical knowledge needed by teachers and the remedy for the problem of obtaining that knowledge remains an issue. Some of the most extensive work in this area comes from Hill, Schillings, and Ball (2004). They examined both the nature of mathematical knowledge needed to teach and the relationship between this knowledge and student learning. Taking a multidimensional approach to measuring content knowledge, they argued that although much has been done to research teachers' content knowledge, further work is needed to precisely map the knowledge needed for *teaching* mathematics. In developing their Learning Mathematics for Teaching (LMT) (Hill, Schillings, & Ball, 2004) instruments, they have made progress in using test items designed to identify specific knowledge and reasoning that is important for teaching mathematics from a reform perspective including generating representations, interpreting student work, and analyzing student mistakes.

Research Questions

In the Mathematics Education Research Project (MERP) we examine three constructs: mathematics pedagogical beliefs, teaching efficacy beliefs, and specialized content knowledge. We ask:

- How do elementary preservice teachers' mathematics pedagogical beliefs and teaching efficacy beliefs change during a teacher preparation program?
- What is the relationship between elementary preservice teachers' mathematics pedagogical beliefs and teaching efficacy beliefs during a teacher preparation program?
- What is the relationship between elementary preservice teachers' mathematics beliefs and their specialized content knowledge for teaching mathematics at the end of a teacher preparation program?

Methodology

Participants and Setting

The participants in this study were elementary preservice teachers enrolled in a two-year undergraduate teacher education program at Georgia State University. A total of five cohorts of students ($n = 103$) are included in our results. Students within a cohort are admitted concurrently and complete all education courses together. The old program consisted of four semesters of coursework which included two mathematics methods courses taught in consecutive semesters. Each of the first three semesters included two-day-a-week field placements followed by a semester of student teaching. The field placements and coursework followed a developmental model with preservice teachers starting their placements in pre-kindergarten and finishing in fifth grade prior to student teaching. Other mathematics requirements in the program included two mathematics content courses for teachers taught through the mathematics department in addition to any university requisite mathematics coursework.

The mathematics methods courses were taught by faculty in the elementary education department who share a common philosophical orientation toward the teaching and learning of mathematics. Thus across the courses the focus was consistent with the constructivist paradigm espoused by the *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics, 2000) in that all students should learn important mathematical concepts and processes with understanding. The preservice teachers were exposed to the features of a *Standards-Based Learning Environment* with a focus on the processes of problem solving, representations, communication, connections, and reasoning and proof. Important goals of the courses included developing (a) beliefs consistent with the perspective of the *Principles and Standards*, (b) understanding of children's thinking about important mathematics concepts, (c) abilities to create problem-solving learning environments for children to facilitate discourse and understanding, and (d) abilities and confidence as a lifelong learner and doer of mathematics. The

first methods course focuses on content and pedagogy for pre-kindergarten through second grade students with field placements in those grades. The second course emphasizes third through fifth grades with corresponding field placements.

Instrumentation

Two instruments, the Mathematics Beliefs Instrument (MBI) and the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI), were administered to the participants four times during the teacher preparation program. In addition, the Learning Mathematics for Teaching Instrument (LMT) was administered at the end of student teaching.

The MBI is a 48-item Likert scale instrument designed to assess preservice teachers' beliefs about the teaching and learning of mathematics and the degree to which these beliefs are cognitively aligned (Peterson, Fennema, Carpenter, & Loef, 1989, as modified by the Cognitively Guided Instruction Project). The three subscales include: (a) relationship between skills and understanding (CURRICULUM), (b) role of the learner (LEARNER), and (c) role of the teacher (TEACHER). The 16 item CURRICULUM subscale examines the degree to which teachers believe that mathematics skills should be taught in relation to understanding and problem solving. The LEARNER subscale contains 15 items that assess the degree to which teachers believe that children can construct their own mathematical knowledge. The 17 items on the TEACHER subscale address the extent to which teachers believe that mathematics instruction should be organized to facilitate children's construction of knowledge. The instrument uses a Likert scale with five response categories (strongly agree, agree, uncertain, disagree, and strongly disagree) with higher scores indicating beliefs that are more cognitively-aligned. These subscales have high reliability (Chronbach's alpha = .80 for CURRICULUM, .89 for LEARNER, and .90 for TEACHER) and represent independent constructs based on confirmatory factor analysis.

The MTEBI consists of 21 items, 13 on the Personal Mathematics Teaching Efficacy (PMTE) subscale and 8 on the Mathematics Teaching Outcome Expectancy (MTOE) subscale (Enochs, Smith, & Huinker, 2000). The two subscales are consistent with the two-dimensional aspect of teaching efficacy. The PMTE subscale addresses the preservice teachers' beliefs in their individual capabilities to be effective mathematics teachers. The MTOE subscale addresses the preservice teachers' beliefs that effective teaching of mathematics can bring about student learning regardless of external factors. The instrument uses a Likert scale with five response categories (strongly agree, agree, uncertain, disagree, and strongly disagree) with higher scores

indicating greater teaching efficacy. These subscales have high reliability (Chronbach’s alpha = .88 for PMTE and .81 for MTOE) and represent independent constructs based on confirmatory factor analysis.

The LMT examines teachers’ specialized content knowledge for teaching mathematics (Hill, Schilling, & Ball, 2004). The instrument assesses this knowledge by posing mathematical tasks that reflect what teachers encounter in the classroom such as assessing students’ work, representing mathematics ideas and operations, and explaining mathematical rules or procedures. Content knowledge subscales in this instrument include: (a) number and operations, (b) patterns, functions, and algebra, and (c) geometry (Hill & Ball, 2004). Content validity was established by mapping items for congruence with the National Council of Teachers of Mathematics Standards (Siedel & Hill, 2003). Analysis of reliability indicated alpha coefficients of .79 for the number and operations subscale, .75 for the patterns, functions, and algebra subscale, and .85 for the geometry subscale (G. Phelps, personal communication, October 6, 2006).

Table 1 shows points of data collection for instruments, the sequence and length of placements, and when the mathematics methods courses were completed.

Table 1
Sequence of Teacher Preparation Program and Data Collection

	Semester 1	Semester 2*	Semester 3*	Semester 4*
Mathematics methods courses	None	cus on PreK-2 mathematcus on 3-5 mathemati		None
Field Placements	PreK – 5 weeks K – 9 weeks	1st – 7 weeks 2 nd or 3 rd – 7 weeks	4 th – 7 weeks 5 th – 7 weeks	Student teaching
Administration of MBI & MTEBI (Four times)	None	(1) INITIAL Week 1 (2) POST 1 Week 14	(3) POST 2 Week 14	(4) FINAL Week 14
Administration of LMT (one time)	None	None	None	(4) FINAL Week 14

*Asterisks denote semesters included in this study.

Results

Mean scores and standard deviations across the administrations of the MBI subscales and MTEBI subscales are provided in Table 2. Table 3 indicates the statistical significance of the differences between these means using Wilks’ Lambda and its associated F-statistic.

Table 2
*Means and Standard Deviations for Pedagogical Beliefs and Mathematics Teaching Efficacy Scores**

Subscale	Means				Standard deviations			
	Initial	Post 1	Post 2	Final	Initial	Post 1	Post 2	Final
CURRICULUM	3.04	3.25	3.33	3.34	.32	.47	.43	.49
LEARNER	3.08	3.38	3.55	3.55	.43	.49	.49	.60
TEACHER	3.31	3.60	3.71	3.77	.39	.45	.53	.58
PMTE	3.54	3.71	3.94	4.18	.56	.56	.56	.65
MTOE	3.44	3.50	3.63	3.64	.40	.43	.50	.51

* Represented on a five point Likert scale

As indicated in Table 3, the preservice teachers had significant increases in overall CURRICULUM, LEARNER, and TEACHER subscales scores. The preservice teachers' beliefs became more cognitively-aligned during the teacher preparation program with these significant changes occurring across the semesters they were enrolled in the two methods courses with the exception of the CURRICULUM subscale during the semester of the second methods course. During student teaching the scores on these three subscales remained largely unchanged.

Table 3
*F-Values (p-values) for Pedagogical Beliefs and Mathematics Teaching Efficacy Scores**

Subscale	Overall	Initial to Post 1	Post 1 to Post 2	Post 2 to Final
CURRICULUM	19.35 (.000)	29.28 (.000)	3.13 (.080)	.138 (.711)
LEARNER	37.76 (.000)	44.74 (.000)	13.14 (.000)	.002 (.968)
TEACHER	33.37 (.000)	55.86 (.000)	4.77 (.031)	1.20 (.276)
PMTE	26.22 (.000)	11.02 (.001)	20.90 (.000)	10.51 (.002)
MTOE	6.88 (.000)	1.83 (.179)	6.04 (.016)	.02 (.883)

*For the overall comparisons, df = 3, 100; for all other comparisons, df = 1, 102

Data from the PMTE subscale revealed the preservice teachers had significant increases in their overall personal efficacy for teaching mathematics (see Table 3). These significant mean increases in scores occurred consistently throughout the program across the semesters of both methods courses and into student teaching. MTOE subscale scores also showed significant increases during the teacher preparation program. The preservice teachers' outcome expectancy beliefs significantly increased with this change largely occurring during the semester of the second methods course and these beliefs remaining essentially constant during student teaching.

Correlations between teaching efficacy beliefs and pedagogical beliefs across the administrations are provided in Table 4. At the beginning of the semester of the first methods course, there were no significant relationships between PMTE and MTOE subscale scores and CURRICULUM, LEARNER, and TEACHER subscale scores. However, at the end of the semesters after the first and second methods courses as well as after student teaching the PMTE and CURRICULUM, LEARNER, and TEACHER subscale scores were positively related with slight to moderate correlations. In addition, in general, the MTOE and CURRICULUM, LEARNER, and TEACHER subscale scores had slight, positive relationships at the end of the semesters of the first and second methods course as well as student teaching.

The results of the correlation analysis also revealed some significant relationships between specialized content knowledge and beliefs at the end of student teaching (see Table 4). The preservice teachers' scores on the LMT were slightly, positively related to CURRICULUM and LEARNER subscale scores. However, there were no relationships between the LMT scores and TEACHER, PMTE, and MTOE subscale scores.

Table 4

*Pearson Product Moment Correlations between Pedagogical Beliefs, Mathematics Teaching Efficacy, and Specialized Content Knowledge Scores**

Subscale	PMTE				MTOE				LMT Final
	Initial	Post 1	Post 2	Final	Initial	Post 1	Post 2	Final	
CURRICULUM	-.018	.289**	.389**	.380**	.020	.175	.292**	.336**	.238**
LEARNER	.098	.257**	.377**	.452**	-.088	.216**	.363**	.303**	.224**
TEACHER	.004	.380**	.429**	.593**	-.040	.257**	.367**	.320**	.127
PMTE									.058
MTOE									-.169

*n = 103

**Correlation is significant with $p < .05$

Discussion

This study examined three constructs during a teacher preparation program: pedagogical beliefs, teaching efficacy beliefs, and specialized content knowledge for teaching mathematics. Over one hundred preservice teachers in five different cohorts were studied during the two years of their teacher preparation program. The program took a constructivist approach to mathematics teaching and learning, attempting to provide experiences for students that encouraged alignment

of beliefs with current reform recommendations. The students experienced a two-course mathematics methods sequence that aligned developmentally with their grade level field placements. Our results are interpreted within the framework of this program.

Changes in Beliefs

Our first research question focused on *changes in beliefs* during the program. The preservice teachers' mathematics pedagogical beliefs about the relationship between skills and understanding (CURRICULUM subscale) and the role of the teacher (TEACHER subscale) and learner (LEARNER subscale) became more cognitively-aligned during the teacher preparation program. The significant shifts occurred across the semesters they were enrolled in the two methods courses, with one exception. The subscale which measures beliefs that skills should be taught in relation to understanding (CURRICULUM) did significantly increase during the first methods course but not during the second methods course. During student teaching the preservice teachers' pedagogical beliefs as measured by the three subscales remained stable.

Overall, increased alignment of pedagogical beliefs with a cognitive orientation and hence a reform perspective during the two-semester methods sequence is consistent with earlier research on change during methods courses (Author, 2002; Lubinski & Otto, 2004; Spielman & Lloyd, 2004; Wilkins & Brand, 2004). The methods coursework immersed students in a reform perspective, and they were given opportunities to experience success in implementing reform practices in their field placements. They were supported by mathematics education faculty and frequently saw the benefits of a constructivist perspective to teaching and learning.

Some of the results from our question on change are of particular interest. First, after a significant change in preservice teachers' beliefs that skills should be taught through problem solving and with understanding (CURRICULUM subscale) during the first methods course these beliefs did not significantly increase during the second methods course. Since the academic focus during the second methods course is grades 3, 4, and 5, it is hypothesized that this experience had a differential effect on beliefs about curriculum implementation. The preservice teachers may have found less alignment of practices in their field placements with more emphasis on the mastery of individual skills in isolation than demonstrated in their methods course, resulting in a leveling of the belief that skills should be taught in relation to understanding.

A second interesting finding related to change in beliefs is that all three pedagogical beliefs subscale scores essentially remained the same during student teaching. The maintenance of the

preservice teachers' beliefs during student teaching is promising, since the more traditional practices often experienced in the field can be counter intuitive to beliefs learned during university experiences. Maintenance of cognitively-aligned pedagogical beliefs provides optimism that those beliefs may be more secure and carried forward into the actual classroom decision-making of these future teachers. The particular programmatic features experienced by the preservice teachers, including the two course mathematics methods sequence and time- intensive, developmental field placements, seemed to have established these cognitively-oriented beliefs and allowed for stabilization during student teaching.

Across the program the preservice teachers consistently developed stronger beliefs in their skills and abilities to teach mathematics effectively as indicated by the PMTE subscale. The support provided by the two methods courses as well their experiences in student teaching not only sustained but increased their personal teaching efficacy beliefs. The preservice teachers were exposed to what Bandura (1977) has emphasized as two important sources of efficacy beliefs: mastery and vicarious experiences. The preservice teachers had significant field experiences (2 days per week) during both methods courses and complete immersion in the field during student teaching; this gave ample opportunity for successful mastery experiences in teaching mathematics. Furthermore, the preservice teachers were exposed to successful models of mathematics instruction from the instructors of the methods courses and some of the cooperating teachers in the field placements.

Outcome expectancy beliefs, or the preservice teachers' beliefs that effective teaching of mathematics can bring about student learning regardless of external factors, also increased during the program as indicated by the MTOE subscale. This increase largely occurred in the second methods course with the beliefs remaining essentially the same during student teaching. Earlier studies indicate that preservice teachers' outcome expectancy beliefs significantly decline during student teaching (Hoy & Woolfolk, 1990). This decrease in beliefs is attributed to the unrealistic optimism of preservice teachers toward impacting student learning prior to the immersing student teaching experience. Perhaps the substantial field experiences of the preservice teachers in this study prior to student teaching somewhat tempered this expectation and contributed to this positive finding in that these beliefs remained consistent during student teaching.

Interrelatedness of Beliefs

Our second research question examined the *interrelatedness of beliefs* throughout the program. At the beginning of the first methods course, there were no significant relationships between teaching efficacy beliefs (PMTE and MTOE subscales) and pedagogical beliefs (CURRICULUM, LEARNER, and TEACHER subscales). Given the emphasis in the methods courses on teaching from a reform perspective, it is not surprising to find that there were, in general, positive relationships after the first and second methods courses and student teaching. Throughout the program, the preservice teachers who had stronger beliefs in their skills and abilities to teach mathematics effectively generally had more cognitively-oriented beliefs toward the teaching and learning of mathematics. In addition, the preservice teachers who believed more strongly that effective teaching of mathematics could bring about student learning regardless of external factors generally held more cognitively-oriented beliefs toward mathematics instruction.

Interrelatedness of Beliefs and Specialized Content Knowledge

Our third research question addressed the *interrelatedness of beliefs and specialized content knowledge* after the program. The preservice teachers that had more specialized content knowledge for teaching mathematics (LMT) were more likely to believe that children can construct their own mathematical knowledge (LEARNER subscale) and that mathematics skills should be taught with understanding (CURRICULUM subscale). However, there were no relationships between the specialized knowledge for teaching mathematics (LMT) and beliefs that mathematics instruction should be organized to facilitate children's construction of knowledge (TEACHER), beliefs toward personal teaching efficacy (PMTE subscale), and teaching outcome expectancy (MTOE subscale). What is interesting in these results is the disconnect between preservice teachers' specialized content knowledge and their belief in their skills and abilities to teach mathematics effectively. It appears that preservice teachers can be quite efficacious about their teaching and not have developed strong specialized content knowledge for teaching mathematics. This naïve perspective is not surprising and is consistent with the human condition of not being aware of what you do not know.

Conclusions

Although preservice teachers enter teacher preparation programs with relatively well-entrenched beliefs about mathematics teaching and learning (Pajares, 1992), our results suggest that programs can have an impact on those beliefs. Consistent with other research, we found that during their coursework, preservice teachers developed beliefs more consistent with a reform

perspective and became more efficacious about their skills and abilities to teach mathematics effectively and to influence student learning. Even during student teaching, personal teaching efficacy continued to increase while teaching outcome expectancy and pedagogical beliefs remained stable. It is optimistic that this enculturation experience in the schools did not undermine teacher change. The stability of these beliefs during student teaching seems to suggest that the distinctive features of the teacher preparation program, including two semesters of mathematics methods and time-intensive, developmental field placements, helped in developing well-established beliefs.

The pattern of our results is consistent with the view that both teaching efficacy and pedagogical beliefs are comprised of multiple constructs. We have added to this literature by showing that beliefs about the role of the learner, the teacher, and the relationship between skills and understanding in mathematics as well as personal teaching efficacy and teaching outcome expectancy vary over time and interact in different ways with each other and with other factors that influence mathematics teaching. One manifestation of this multi-dimensional aspect of beliefs is preservice teachers' *relative* resistance to change in their beliefs about teaching outcome expectancy and the relationship between skills and understanding in mathematics when compared to their personal teaching efficacy and beliefs about the roles of the teacher and learner. These two belief constructs were the only ones that did not consistently and significantly increase across the two methods courses. They also remained largely unchanged during student teaching.

In considering the findings of our study, we obviously cannot assert that the changes that occurred over the three semesters in our program will continue as these preservice teachers enter into their own classrooms; that is for another study. Also, we cannot confirm that the beliefs that they espouse will manifest themselves in classroom decision-making and practices with their own students. The conflict between espoused beliefs and beliefs in practice is a viable concern (Wilson & Cooney, 2002). Teachers who continue to hold reform beliefs are often hesitant to implement them within the culture of a traditional school setting (Hart, 2004). However, by carefully examining the process of change during the two years in a teacher preparation program and studying the interaction of the constructs that affect change, we are better informed about how to construct our program, which may assure more lasting change as preservice teachers make their way into their professional careers.

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