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Karim Medico Letwinsky[1], Monica Cavender[2]
[1]Wilkes University
[2]Quinnipiac University

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Shifting Preservice Teachers Beliefs and Understandings to Support Pedagogical Change in Mathematics

Karim Medico Letwinsky, Monica Cavender

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Abstract

Many preservice teacher (PST) programs throughout the world are preparing students to implement the Core Standards, which require deeper conceptual understandings of mathematics and an informed approach for teaching. In this qualitative multi-case study, researchers explored the teaching methods for two university instructors and changes in PSTs beliefs previously formed by personal elementary experiences. Results of the pre- and postcourse analysis demonstrate notable shifts in beliefs, understandings, and personal philosophies. A situated context and a social constructivist approach coupled with critical reflective exercises created an environment for PSTs to reflect upon and change their personal conceptual frameworks.

Introduction

Informed by decades of research from the National Council of Teachers of Mathematics (NCTM), the Core State Standards for Mathematics (CSSM) have been widely adopted across school systems in both the United States (CCSSI, 2014) and internationally (International Baccalaureate Organization [IBO], 2015). The International Baccalaureate (IB), a global curriculum for approximately 50 years, recognizes how this framework has impacted US schools and IB schools worldwide as a relevant and rigorous structure for teaching mathematics. Such strong influences in education and the direction of mathematics curriculum, teaching, and learning have caused teacher education programs worldwide to reexamine the pedagogical practice of instruction and assessment in grades K- 12. As mathematics education moves away from a fragmented, component skills approach toward a conceptual approach in which mathematics is taught in a constructivist framework (Fives & Buehl, 2010), the shift in pedagogy emphasized must center around the student's ability to make meaning, reason, communicate, and problem solve (NCTM, 2014).

This most recent reform effort requires deeper and broader understanding of mathematics by teachers (Kajander, 2010). In fact, the current changes in mathematical content and teaching practice demand both an advanced perspective of complex thinking and a revised approach with pedagogical strategies (Kajander, 2010). The reformed approach to learning mathematics requires elementary mathematics instruction to undergo a profound change in its theoretical orientation and pedagogy to support the implementation of the intended shifts inherent in the Core Standards. As such, teacher education programs must intentionally design courses to ensure that preservice teachers (PSTs) are equipped with the knowledge, skills, and dispositions necessary to support this paradigm shift. Upon entering the teaching profession, PSTs may be tasked with implementing the Core Standards for Mathematics, yet they have not experienced education guided by the ideals of these Standards. Current PSTs likely are more familiar with traditional teaching approaches to mathematics (Burns, 2007; Dede & Karakuş, 2014; Kajander, 2010). This may limit both their understandings of mathematical concepts, as well as their beliefs about effective teaching of mathematics (Lannin & Chval, 2013).

The design of the Core Standards for Mathematics is such that not only does it address what should be taught in K-12 mathematics, but attention also is given to *how* mathematical content should be taught. This is clearly articulated in the Standards for Mathematical Practice as well as in the Key Shifts in Mathematics explained by the creators of the Core Standards initiative (CCSSI, 2014). As reform in teaching mathematics collides with the instructional foundations that many individuals experienced as learners (White-Clark, Di Carlo, & Gichriest, 2008), challenges exist in overcoming beliefs grounded in previous procedurally focused experiences to enhance the valuing of conceptual learning by teachers. For many PSTs, mathematics consisted of learning a procedure taught by the teacher and repeated by the students (Feiman-Nemser & Remillard, 1996). This approach limited a student's ability to understand the connected nature of the concepts of mathematics, a necessary factor to form deeper understandings described in the Core Standards. A critical component to teacher education programs is addressing the complex link between how students have learned mathematics themselves and how they are expected to teach elementary mathematics (Lannin & Chval, 2013).

The intent of this qualitative, multi-case study was to better understand the influences on PSTs in elementary teacher preparation programs. The authors investigated the question, "How is teacher preparation influenced when PSTs engage in an elementary mathematics methods course focused on conceptual learning and critical reflection?" The results produced evidence of a shift in personal philosophy and epistemology, perceived mathematical conceptual understandings, and pedagogical beliefs. These findings provide a platform for discussions about elementary mathematics method course design.

Theoretical Framework

The social constructivist theory grounded this study and emphasizes a pedagogical approach that includes an active role of the student in building understanding and making sense of information in a social environment (Vygotsky, 2004). The student plays a key role in the constructivist approach, and maintaining motivation to learn is often dependent upon the student's ability to make connections in personal learning accomplishments. Constructivists look for opportunities of engagement for students and build upon these opportunities to plan future instruction (Dewey, 1938). Similarly, the National Research Council (2000) described the constructivist nature of learning in their three principles of learning, namely the reconstruction of understandings, integration of conceptual frameworks, and metacognitive skills. These principles of learning underscore this study's approach to preservice teachers' development and key literature expanded this approach as it related to both PST education and the teaching and learning of mathematics. The disposition of social constructivism and the fundamental role that others have in the learning process was prominent in the methods course development and delivery by allowing students to engage with one another and the concepts of mathematics, rather than with the instructor as a transmitter of information.

Literature Review

The relevant literature framing this research study is focused on the influence of PST teacher beliefs and self-efficacy during teacher education methodology coursework. Consideration also is given to the value of reflection in the change process and the importance of constructivist teaching strategies that promote the development of conceptual understandings in elementary mathematics content. The principles describing the intimate connection between constructivist strategies and the value of reflection in this study stemmed from the work done by Perkins (1998). He purported a constructivist view of understanding, asserting that understandings develop during purposeful reflection, through performance of knowledge and skills, by building upon previous understandings, and by challenging misunderstandings or misconceptions.

The Relationship between Reflection and Changing Beliefs

In 1992, Pajares reaffirmed the significant impact that PSTs beliefs have in forming teacher practice, and current research continues to support this position (Wilkins, 2008). Pajares (1992) promoted the need to gain a clear understanding of teacher beliefs because these beliefs may promote or resist the potential impact of teacher education programs. In fact, in 1979, Fensternmacher predicted that understanding PSTs beliefs would be a focal point for research exploring teacher effectiveness. Current research shows that PSTs enter teacher preparation programs with a skewed vision and belief system related to the teaching and learning of mathematics formed by previous negative experiences (Greshman, 2009; Grossman et al., 2009). These pre-existing beliefs and negative experiences hold a prominent place in elementary PSTs intentions for future teaching. Neglecting to address these misconceptions and making intentional efforts to dismantle and replace prior negative experiences, may result in teacher preparation programs having little or no impact on PSTs future practice. As the paradigm of teacher educational practices shifts with the implementation of the Core Standards, research such as this that takes an explicit approach to have PSTs critically reflect upon their own beliefs and provide experiences that may facilitate a systemic change in those beliefs and intended future practice is timely.
Ernest's (1989) conceptual model emphasized the relationship between the knowledge, beliefs, and attitudes of a mathematics teacher. Mathematical content knowledge has a direct relationship with instructional practices (Ernest, 1989), and instructional practices are directly informed by teacher beliefs. Wilkins (2008) found that teacher beliefs have the strongest effect on teachers' practice, and so a deeper understanding of shifting PST

beliefs appears to be imperative for authentic and sustainable change to occur. To support this change, the value of reflection related to one's personal beliefs cannot be understated. In fact, Jay and Johnson (2002) suggested that reflection was an integral part of PST education. The roots of reflective practice and the direct connection to beliefs can be attributed to Dewey (1933) where it was defined as, "thinking that is the active, persistent and careful consideration of any belief or supposed form of knowledge in light of the grounds that support it and the further conclusions to which it leads" (p. 9). By engaging PSTs in reflection exercises designed to examine their personal belief system, PSTs have the opportunity to autonomously challenge their beliefs directly as they progress through methods courses.

According to Richardson (1990), the widespread value of reflection in teacher education increased with the work of Schön in the mid 1980s. Schön (1987) defined reflective practice as "a dialogue of thinking and doing through which I become more skillful" (p.31). This perception of reflection provides a focus on the inherent interplay between reflective thinking and teaching with an intention to improve one's current skill. Schön (1987) further explained that reflection in action would involve "making sense of uncertain, unique or conflicted situations of practice" (p.39). This final definition was perhaps the most complex and appropriate to inform this study, involving both thinking and doing while incorporating meaning making. This conceptualization of reflection is integral to this research, as students were led to reflect on their beliefs with the intention of impacting future action related to teaching practice.

Teacher Efficacy

Reform efforts in teaching elementary mathematics will largely depend on how PSTs perceive their level of success when teaching mathematics. The knowledge, beliefs, and attitudes classroom teachers have play a vital role in the shift in thinking toward mathematical reform (Anderson, Walker, & Ralph, 2009; Corkett, Hatt, & Benevides, 2011; Gresham, 2009). Past research suggests that self-efficacy is one of the most powerful influences on receptivity to changing instructional practices (Tschannen-Moran & McMaster, 2009). Implementation of a new view of mathematics relies on the classroom teacher's level of efficacy (Gulcan, 2011). Doubts expressed in their effectiveness lends to avoidance of the content and tension in expression of mathematical ideas (Gulcan, 2011; Tschannen-Moran & McMaster, 2009). High efficacy beliefs show a significant pattern in direct relation to positive instructional practice (Bayraktar, 2009; Cerit, 2010). One result of increased confidence levels in PSTs is a positive self perception. This influences the cognitive and motivational process in teaching that enhances the drive to seek out new teaching ideas (Bruce & Ross, 2008; Hines & Kritsonis, 2010). Because innovative instructional practices motivate learners and support a positive classroom environment, students taught by teachers with high efficacy in mathematics have achieved higher test scores than their counterparts (Carleton, Fitch, & Krockover, 2008; Hines & Kritsonis, 2010).

The Procedural to Conceptual Shift

Effective teaching of mathematics requires not a deeper understanding of standards, but a deeper understanding of teaching (NCTM, 2014). A challenge for PST's exists because weaving together content and pedagogy to maximize understanding is a complex task that must be supported both conceptually and procedurally (Ball, 1988; Shulman, 1986). Many PST's, however, lack deep conceptual understandings of elementary mathematics. To positively impact future classroom practice, methods courses must provide the opportunity to improve not only PST beliefs about mathematics, but also their fundamental conceptual understandings of elementary mathematics (Fennema & Franke, 1992).

Willingham (2010) suggested that creating opportunities for students to understand mathematics conceptually is a complicated task, but that instruction to achieve this must look different than what many PSTs may have experienced in their education. Many PST's have been exposed to predominantly a more traditional approach to learning mathematics (Burns, 2007; Dede & Karakuş, 2014; Kajander, 2010). This foundation not only drives their tendencies towards future teaching practice, but also limits their ability to understand mathematics deeply and conceptually. Some researchers have explored the possible causes of the resistance to the necessary paradigm shift toward conceptual learning and attribute this challenge to a disconnect between how current elementary teachers, themselves, learned mathematics and the methods necessary to support conceptual learning (Burns, 2007; Author 2, 2012). This approach to learning mathematics conceptually collides with many elementary classroom teachers' past learning experiences, making the implementation of a new method challenging (Author 2, 2012).

Method

This research utilized a qualitative approach and a multi case design to gain a deeper understanding of how teacher preparation is influenced by an elementary mathematics methods course focused on conceptual learning and critical reflection. The two course instructors, who served as co-investigators for this study, collaborated extensively on course design and delivery to ensure alignment and consistency. Case one was conducted by one author of this study, and case two by the other. The cases took place in two different states, both at four year institutions in the Northeast region of the United States. Collectively, data were gathered from 57 undergraduate students in elementary teacher degree and certification programs.

Setting and Participants

All PST participants in this study had minimal fieldwork experience with executing an elementary mathematics lesson. Both institutions were private, nonsectarian, and located in a suburban part of each respective state. Each institution conducted elementary mathematics methods courses with 13-15 weeks of instruction and using a similar framework and pedagogical approach.

University A

University A served as case one and consisted of 22 PSTs, all of whom were undergraduate students ranging in age from 20-21. All of the students were enrolled as undergraduates seeking an elementary education Bachelor of Science degree with eligibility for certification in pre-kindergarten through fourth grade. The course was a one semester, mathematics methods course for grades 2-4 that met for 90 minutes, twice a week for 15 weeks. All students in the course were in the third year of their degree program, and while they had performed more than 40 required hours of field observations, none had assumed an actual teaching role in a classroom in the field. To this point in the program, these students had only practiced lessons on their peers.

University B

University B was the site for case two. University B included 35 PSTs who all served as participants. The class was divided into two sections. One section included 16 PSTs who were undergraduate students ranging in age from 20 - 22. The other section included 19 students of similar age and place in the teacher preparation program. The course was a methods course for Teaching K- 2, held once a week for 150 minutes for 13 weeks.

Methods Course Approach

During the semester, instructors provided an intentional situated context (Lave & Wenger, 1991) for PSTs to experience an authentic environment of reformed mathematics, including the re-learning of elementary mathematics. Course design was based upon a social constructivist philosophy to support positive experiences in conceptual understanding through social exchange. The explicit intent of each course instructor was to allow students to experience reformed mathematics approaches, as both mathematics learners and PSTs. Research has shown that teachers are more likely to implement new content and methods when they experience it themselves (Pederson & McCurdy, 1992) and are then given a chance to reflect on their experiences (Abell & Bryan, 1997; Schon, 1984). Unlike some methods courses which may only emphasize teaching methods and classroom strategies related to a content area, the methods courses in this study were designed to focus development in three distinct areas. First, the instruction was planned to enhance conceptual mathematics content knowledge and develop new understandings about elementary mathematics concepts. To accomplish this, PSTs were presented with real mathematics problems from grades 2-4 and asked to collaboratively solve them using manipulatives, drawings, and small group discussion. During the solution process, students were asked to engage in a think- aloud strategy. As highlighted by other researchers, think-alouds have a long and prominent place in qualitative research, specifically as a method for gaining insight into cognitive processes (Garner, 1988; Johnson & Landers-Macrine, 1998) and prompting learners to examine assumptions about learning (Johnson & Landers-Macrine, 1998). One such example was, "*with your group, model and discuss 3 different ways to convince someone that 5/7 is less than 7/5. How do you know this to be true*?" This activity engaged PSTs in authentic elementary learning activities that required communication of reasoning, representation of process, and illustration of conceptual knowledge. Students took turns solving the mathematical problems while speaking their thoughts out loud as they wrestled with the problems. Afterwards, students then engaged in small group dialogue about their collective thinking in response to the problem prompts and solutions. The expression of this inner speech contributed to the social construction of knowledge posited by Vygotsky (1962) and the complex dynamic between inner speech and verbalized thought. During these activities, course instructors circulated through the room as only an observer taking detailed field notes.

PSTs also had to express a deeper representation of the conceptual understanding of content and processes. An example to accomplish this included a hands on activity using fraction strips to represent that one half is equal to two fourths. This process is described as follows:

To begin each student had 5 strips of colored paper. The first strip was labeled one whole. Then each student cut fractional pieces of halves, fourths, eighths, and sixteenths from the remaining strips of colored paper. The cutting of the strips highlighted the various sizes of the fractional pieces. The repetition of cutting, for example the sixteenths, helped enhance the experience of what a sixteenth looked like in comparison to a half. The instructor has the students close their eyes, then when prompted ask to recall the color of individual fractional pieces. This is done to illustrate the value of the experience of cutting strips themselves. The lesson then moves to exploring equivalence. Students are asked to represent multiple formats of equivalence using the physical fraction strips and explain their understanding to a partner. The conceptual building of knowledge and required communication appears simple, yet is often what is valued in the discussion that follows. This is also done so that PSTs repeat this simple yet valuable step with their future elementary students. Independently, PSTs are then asked to transfer their representations of one half to a paper illustration. This independent practice requires students to use pictures, numbers, and words in their response. A sample PST response includes an illustration (representation) of the ½ fraction strip with two ¼ fraction strips underneath and aligned to meet the same length. Each strip is labeled and underneath is ½ = 2/4 along with "I know that one half is the same as two fourths because I can align my fraction strips to the same length. The student will also have additional examples that include ½=4/8 and ½=8/16, explaining in pictures, numbers and words accordingly.

Upon completion of the activity, students were asked to think-aloud again with a small group or the class for how they know this to be true by using the physical model, words, and symbols. The course instructor then facilitated a class discussion and reflection with PSTs answering the questions, "How did this experience help you learn the concept? How does this compare to the way you learned this concept in elementary school?" During both the think-alouds and the follow up discussion, course instructors took detailed field notes.

The second intent of the course was to prompt intentional reflection of teacher candidate beliefs about past experiences and the potential implications of those experiences on future teacher practice. This was accomplished by engaging students in written reflections both at start of the semester and at the end. In addition to the written reflections, PSTs used an online word cloud generating tool to create a word cloud of their pre- and postcourse reflections. Word clouds are images that provide an artistic collage of words generated from the uploaded text and give greater prominence to words that appear more frequently in the source text ("Wordle", 2014). The word cloud offered a visual tool that was useful for students to quickly detect repeated language used when expressing their personal beliefs. The precourse reflection prompt asked for PSTs to write a 2-3 page paper responding to the following:

Describe your earliest memory about learning mathematics. Include the people involved, the environment you were in, and how you felt. The postcourse reflection prompt asked the following: *In a 2-3 page paper, describe your views about teaching mathematics. Include how you viewed learning and teaching mathematics prior to the course as well as how that is reflected in your current beliefs. Use your precourse reflection and word clouds to guide your thinking*. In postcourse reflections, PSTs were asked to compare and discuss the word clouds.

Lastly, and like most methods courses, the instructors sought to inform PSTs intended pedagogical approach for future practice focusing specifically on methods to support the rigor necessary for implementation of Core Standards. The mathematical content sessions focused less on a procedural transmission of facts and skills, but rather allowed for a conceptual understanding of mathematics, rich with student collaboration and the development of mathematics literacy. Content related activities provided authentic learning experiences that maximized the use of mathematics manipulatives and allowed PSTs also to observe the instructor modeling ideal practices to promote conceptual understanding of mathematics (Leaman & Flanagan, 2013). These experiences did not include a traditional use of algorithms or procedural descriptions of performing mathematics, but the course instructor led discussions and activities that allowed PSTs to engage actively with the concept. PSTs frequently collaborated on future methods they could use to create similar learning environments, while reflecting how these new experiences were different from one they had when learning mathematics. This intentional and expanded course design sought to address not only teaching methodology, but also beliefs and understandings because a focus on one without the others has proven unsustainable in future practice (Handal, 2003).

Data Collection

The course delivery provided data from three sources. Data were gathered through pre- and postcourse reflection assignments, which included 148 pages of precourse reflections and 178 pages of postcourse reflections. A word cloud as depicted by Figures 1 and 2 supplemented each reflection.

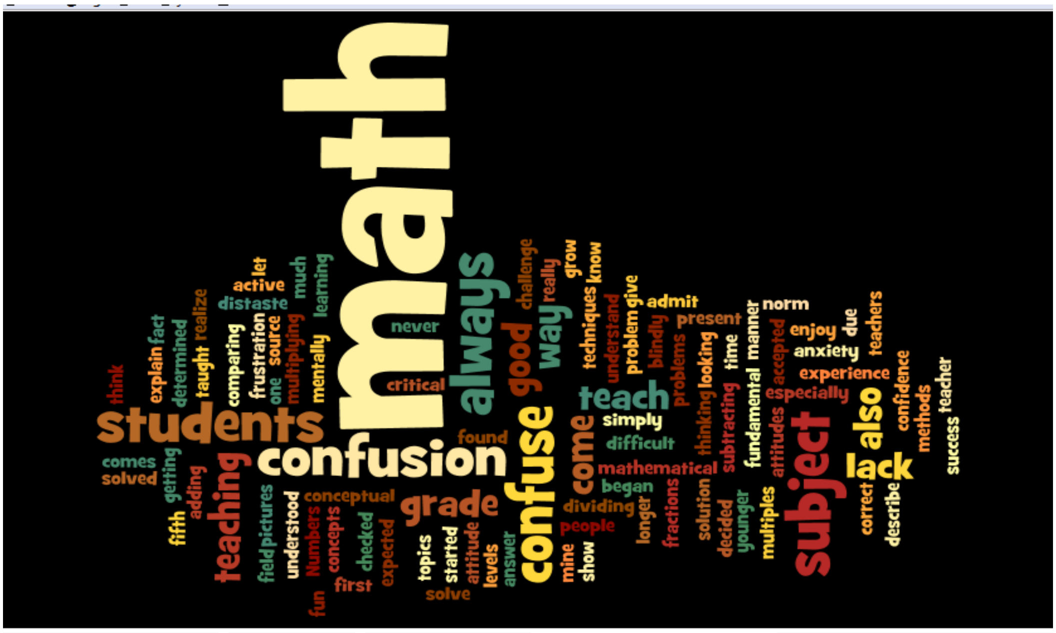

Figure 1. Precourse reflection word cloud

"Two of the largest words in my word cloud were confuse and confusion. I think that these accurately represent my attitude towards math based upon my past experience. I do not want these to be the words that my students associate with math."

Figure 2. Postcourse reflection word cloud

Course instructors recorded detailed field notes during class think-alouds for problem solving, hands on activities, and reflections using the same prompts indicated above. Students were not interrupted during think-alouds to prevent any disruption of inner speech or the actual content of their cognitive process (Ericsson & Simon, 1980). In line with Ericsson and Simon (1980), researchers used this data to support inferences and triangulation

Data Analysis

Designed as a multi case study (Yin, 2009), researchers began by independently performing a within case analysis (Merriam, 1998) for each site. Researchers examined data using the constant comparative analysis as described by Hewitt-Taylor (2001). This incorporated a three stage approach to data analysis which included data from the precourse and postcourse field notes, students' written pre-and post reflection papers, and the pre- and postcourse word cloud images. Each researcher first independently coded the precourse data using an open analysis to uncover within case themes and patterns from each site (Miles & Huberman, 1994). The codes were not identified a priori; rather they emerged from the data and were continually refined through the process. Codes were attributed to statements, paragraphs, or sections of data that were representative of the themes that emerged. Some precourse code examples included, *anxiety, memorization, procedure, and embarrassment.* After each researcher independently coded both within case sets of data, they met to review and discuss codes, any minor incongruences, and bring to light any hidden biases or discrepancies. At that point, the precourse codes were agreed upon for both cases. Researchers performed a similar process for the postcourse data.

In the second stage of analysis and once initial coding of all pre- and postcourse data was complete, researchers merged codes with common elements to form categories (Strauss & Corbin, 1998). After defining each category, coded data was grouped within each category, with some data placed in multiple categories. The final stage of analysis involved the formal development themes in response to the research question. This included evidence in pre- to postcourse data of clear shifts in three distinct areas: personal philosophy and epistemology, perceived mathematical understandings related to conceptual and procedural approaches to mathematics, and pedagogical beliefs. The sequential design allowed for the formal analysis of evidence within each site, the combined cases, and provided comparisons between all pre- and postcourse data.

Establishing credibility and trustworthiness in qualitative research supports validity (Miles & Huberman, 1994), so data were collected and triangulated with multiple pieces of evidence (reflections, word clouds, and field notes). Throughout the course delivery, instructors collaborated frequently for fidelity of implementation of course content and approach to ensure equal processes and exposure to the methods for PSTs at each university.

Findings

This study was designed to answer the research question, "How is teacher preparation influenced when PSTs engage in an elementary mathematics methods course focused on conceptual learning and critical reflection?" The results produced evidence of a pre- to postcourse shift in epistemology, perceived mathematical understandings related to conceptual and procedural approaches to mathematics, and pedagogical beliefs. These findings provide a platform for reflection about elementary mathematics method course design and their ability to influence PST preparation.

Perceptions of Mathematics Self Efficacy

A shift in perceived self efficacy is meaningful because preservice self efficacy adds a cyclical dimension to the level of achievement in the classroom (Hines & Kritsonis, 2010) by continuing to support success. The level of efficacy in content delivery of elementary mathematics plays a considerable role in the learning for effective practices and implementation of the Core Standards in the elementary mathematics classroom. Highly efficacious PSTs have the motivation to provide differentiated instruction and apply creative teaching strategies to support student success (Bayraktar, 2009; Cerit, 2010). Teachers who feel that they have a sense of control over implementation of instructional decision-making have an increased awareness of what best practices look and feel like (Ware & Kitsantas, 2007). High efficacy beliefs show a significant pattern in direct relation to positive instructional practice (Gresham, 2009; Shidler, 2009).

University A

In precourse data from University A, 20 of the 22 PSTs expressed significant anxiety and low self efficacy related to their own experiences with mathematics. For instance, one student reported, "I have no confidence with math and the word itself gives me anxiety". Another student expressed worry about being able to be an effective teacher one day by admitting, "I am very apprehensive about teaching math to a room full of students. I am anxious to teach math because I am not overly confident completing a math problem. Personally I struggle with the concepts and memorizing certain formulas. This student reported the "embarrassment of being labeled a 'winner' or 'loser'" when engaging in timed tests during class and quickly equated being a loser with not being "good at math".

Many students described themselves as not being good at math. One student even surmised that her fellow classmates would express the same sentiment by writing,

> When it comes to teaching math I am very nervous, as I am sure many of my peers are. I think what contributes to my anxiety about teaching math is that I always struggled so much as a young student. The topic of math gives me so much anxiety because it brings me back to such humiliating times in my early education, things like being called on and getting the answer wrong which is the worst thing for a young student. Being such a horrible math student myself makes me very anxious about having to teach math to others. Another student applied this same generalization and humiliation to others by stating, I am unfortunately one of the common students who never really enjoyed math, especially at a young age. I will never forget having quizzes in second grade where I was allotted four minutes to complete an entire times table while crying.

Postcourse reflections for all of the 22 PSTs from University A revealed higher levels of self efficacy, confidence and less anxiety in postcourse reflections. One student simply said, "I feel so much more confident than I did just 14 weeks ago about teaching mathematics". Another student wrote, "I feel more comfortable with math and I am not as intimidated by it as I used to be". All 22 students, even those who demonstrated signs of higher self efficacy in precourse reflections, expressed a new outlook on their ability to teach mathematics that would not be dictated by their past experiences or anxiety.

One student wrote of a desire to continue overcoming her perceived deficiencies related to her anxious feeling about teaching mathematics by writing,

> One thing I have learned in this class is that even if it does not ever go away, I am okay with that. This is where I believe I have become more confident with teaching math. I believe this class taught me that math is evolving so as I progress as a teacher through the years, I will need to continue my education just like my students, and with my students.

Two of the students admitted an ongoing struggle with feeling confident teaching mathematics one day. One in particular wrote,

> Although having these tools I have learned in class ease my anxiety, I still have anxious feelings that I do not think will disappear until I actually begin teaching. Because I always thought that I was never good at math, there is still that thought in my mind "How am I going to teach math if I am not even good at it myself?"

Several students expressed higher efficacy and empowerment by referring to their own deeper understandings of the content and the new tools for teaching that once were unfamiliar to them, such as technology, manipulatives, communication, and writing. Supporting this, one student wrote, "I have already learned a few new ways to solve math problems and I have learned how to use manipulatives and ways to work with them". Another student reflected on a lesson she developed by claiming, "As I was writing the fraction lesson, I could picture the students really enjoying it which could help them not be afraid of fractions".

University B

Out of the 35 PSTs 27 students' precourse reflections revealed past experiences with learning mathematics as negative which therefore led to a low confidence in ability to support student learning in mathematics. For instance, one student captured a common point of view by reporting, "I have always been a student that struggled with math. One of my biggest fears with becoming a teacher is my lack of math skills and that I wouldn't be able to help my students because I don't understand math myself." Another shared, "I was pulled out during math time for extra help in elementary school. In middle and high school my parents had to hire a tutor to help me just get through the basic math courses."

Of the 27 PSTs with negative learning experiences, 23 expressed experiences with prominently direct teaching models that consisted of showing a procedure, providing practice, and then evaluating the recall of that procedure to measure the level of success in mathematical thinking. One student simply said,

> I hated math in school. One of the reasons was because I was given one way to solve a problem and told to mimic that procedure. Then I was graded on how many answers I got correct from copying what the teacher told us in class. It was overwhelming and stressful. I didn't see the point. I didn't enjoy math class. I don't look forward to teaching math. I am hoping someone else will do it.

Another recorded, " We were always given loads of problems to practice in silence. I was a good student, but found it so boring. I don't know how else to teach math though."

Post course evidence for 34 of 35 PSTs demonstrated an increase in positive disposition. One, however, expressed minimal growth. A majority of PSTs expressed enhanced insight to not only how mathematics could be taught, but also gained deeper understandings of the content of mathematics. Commonly students reported, "I feel like I could teach math by asking students to share their thinking. I can see how this would inform my lessons if I could see kids express their understanding in pictures, numbers, and words." Others relayed a comfort in expressing multiple approaches to representing mathematical ideas and acceptance of diverse justifications demonstrated through communication of words, pictures, manipulatives, and writing. One student reported the view shared by many students by stating, "By allowing us to reach our own answers, we are creating a process rather than just performing a task of rote memorization."

PSTs were more comfortable in planning differentiated lessons and using student work samples to plan effective teaching practices because they had experienced the renewed sense of success themselves. This was evidenced by statements such as, "I understand math better than I did when I was in school... I wish I would have had the opportunity to learn this way...I can see how having the opportunity to share one's own thinking and reasoning would make math more engaging and meaningful." Another student reported,

> If I would have had the opportunity to come up with my own reasoning, I think I would have been less anxious about trying to follow the teacher or textbook way. I wish I could have had the opportunity to come up with my own strategy and explain how it worked. I can see how this would work with kids.

The pattern of increased views of self-efficacy was further represented by comments such as "I have a large set of resources now to use as a menu when planning lessons for individual needs. I look forward to teaching math." Another student expressed a newly found confidence by stating, "When doing mathematics, elementary students need to have time to share their thinking and have tools to represent their ideas in multiple ways."

Beliefs about Teaching Mathematics

Individual perception of teaching capabilities also influences the belief level of successful teaching practice and teacher competence (Bayraktar, 2009; Delle Fave & Caprara, 2007; Tschannen-Moran & McMaster, 2009). The level of confidence affects the framework of instructional decision-making, and Bayraktar (2009) described a lack of confidence in teachers to use their ability to teach as a contributing factor in low success rates of differentiated instruction. Of the 57 PSTs at both institutions, 50 began the methods course with beliefs that included a narrow and traditional perspective about teaching mathematics. Their descriptions focused on rote strategies like memorization, practice, flashcards, and speed. Language consistent with the constructivist approach and more appropriate for implementation of the Core Standards originally was vacant from all 57 PSTs at both sites. Expanding and changing those core beliefs from previous experiences has been challenging mathematics reformers who have tried to guide the field with constructivist frameworks (Andrew, 2007).

University A

When discussing beliefs about teaching mathematics, memorization emerged as a significant theme in all but 1 of the 22 student reflections. This remains similar to previous findings that students believe learning mathematics meant memorizing a set of rules or procedures with little need for personal understanding (Ball, 1990). Several students referred to memorizing for speed with methods using “timed tests for fact recall”, while another wrote about the repetitious use of flashcards and races with the score being kept on the board for the class to see. Supporting this position, another wrote about earning a “Bulldog button for completing timed addition, subtraction, multiplication, or division worksheets with 100% accuracy”. When referring to teaching and learning, one claimed “mathematics was what we memorized to pass the test”.

When projecting their current beliefs and the possible impact on teaching mathematics, students consistently expressed an understanding of the critical role of their future position as a teacher of mathematics and the desire to not perpetuate similar mentalities. One student wrote, “Being able to teach math to young children is an important job to me because I don't want children to feel the way I did about math when I was there age”. Another said, “I will try my hardest not to bore them, or belittle them in any way”. All 22 PSTs expressed a desire to build confidence, and not fear or anxiety in their students.

In postcourse reflections five PSTs discussed the need for students to construct their own knowledge through self-created algorithms, rather than teachers merely demonstrating process. The need to understand concepts in a logical way was expressed by eight PSTs, as well. For example, one student wrote, “It is not just about memorizing the formula; it is about understanding logically why we are doing it.” All 22 students discussed the desire to teach mathematics differently and in a way that would help students be confident. Specifically, one student said, “The other reason why I want to teach math is to teach students in a different way and approach then the way I learned. That way, students will not grow up to be intimidated or anxious about math, leaving them discouraged like I was.”

University B

Of the 35 PSTs, 28 described themselves as poor in math with statements like, “I was never a good math student and often found myself struggling to just copy down the teacher’s actions step-by-step and then repeat them on the practice pages.” Another recalled, “I couldn’t memorize well, so I never really did well in math. Sometimes I could memorize it for the test, but then forget it again afterwards.” For some, there was an opinion that learning mathematics was more of an inherent capability. Supporting this position, two students paralleled in their view when stating, “There are some people that have a brain for learning math and others that just don’t have the ability.” One student explained the influence of her family and how she was always told “her mother was not good at math”, so it probably just wasn’t her thing. This created a sense that when teaching mathematics only some of their students would actually attain a depth in the knowledge and skill of mathematics and others would gain only a general sense but not understand the reasoning.

Nine students expressed memorization as a successful experience for some while 14 others endured tests with speedy recall claiming, “math was difficult and disconnected.” Those who were fast understood mathematics as memorizing facts and procedures. Students who remembered being slow to recall or challenged by procedures established a sense of anxiety and low self-esteem. Because of these early experiences, a negative perception of teaching mathematics was a prominent theme.

Student postcourse reflections revealed an understanding that teachers must allow opportunities for a variety of representations of thinking. Using manipulatives regularly as well as written and spoken words to justify representations was relayed as being critical in developing a mathematical community of learning. This was evidenced by comments such as “...often there is only one right answer in math, but there can be multiple ways to represent how to get to that answer.” Another PST noted, “math is fun and a time to talk about ideas instead of sitting quietly doing worksheets.” A majority of the group, 30 of 35, expressed in some way that mathematics can and should be engaging for all learners. This reflected a shift in the belief that was grounded previously in procedural recall. Positive dispositions and shifts were reflected in comments such as “I like this way of learning math.” And, “I want to share this with my nephew who is in 3rd grade.”

Pre- to Postcourse Analysis

Upon conclusion of the within case analysis, a pre- to postcourse analysis revealed common shifts across both sites. Significant shifts occurred in the vast majority of students from both sites who initially reported anxiety and low self efficacy, with notable shifts occurring in all students despite their original disposition. During the pre- to postcourse analysis, three sub-themes emerged: one focused on personal philosophy and epistemological perspectives, another focused on perceived mathematical understanding, and the last concentrated on pedagogical beliefs.

Personal Philosophy and Epistemological Shift

Many students suggested changes in personal philosophy and epistemology related to learning mathematics. Only 6 out of the 57 PSTs expressed a positive mathematics self efficacy prior to taking the course. Interestingly, all six of students who did not report negative past experiences revealed changes in beliefs and understandings similar to those revealed by their less efficacious peers. An epistemological transformation was present for a majority of students from both sites in language that no longer accepted the position that a person is "just not good at math". For instance, one student who originally believed that "math success is genetic...some people can do math and others just can't", later reported that "everyone can be successful doing math if given the chance to express their own views". This same student expressed a change from beliefs grounded in traditional approaches to mathematics to that which represented a constructivist philosophy. The reference to expressing one's own views is more consistent with a constructivist teacher who Andrew (2007) described as one who uses classroom strategies that allow students to develop, reflect, evaluate, and modify their own internal conceptual frameworks. Another student similarly wrote, "I used to think math was about getting the right answer, now I realize it is more about being able to explain and understand the process . . .I never realized how much language and communication should be part of learning math".

Perceived Mathematical Understandings

A second theme that emerged was a perceived change in mathematical understandings. Between the two sites, seven PSTs expressed that learning math was easy for them and that they felt confident in their ability to teach at the elementary level. Two of these 7 PSTs were math majors and reported a comfort with flexible representations of mathematical concepts. The same 2, however, acknowledged they enjoyed math because they were successful in multiple courses, yet were unsure as to how to present the concepts in an elementary setting. Relative to this, one student who first reported learning mathematics through algorithms and a "series of disconnected concepts to be memorized", later wrote that she could now be confident "representing and explaining concepts in multiple ways with a variety of tools". Further support of this theme was evident when another student wrote, "I used to think I was good at math, but I realized I could never explain how or why I solved a problem a certain way. I just did what the teacher did. Now I feel like I get it." One student in a simple but articulate 'ah-ha' moment exclaimed, "Why did no one ever teach me this way before? It makes so much sense now!" Of the total 57 PSTs, 45 directly expressed in some way that they believed they understood actual mathematical concepts better.

Pedagogical Beliefs

The last theme gleaned from data analysis represented a shift in pedagogical beliefs. PST reflections revealed a common desire to teach mathematics differently than how they were taught. Even the 7 of the 57 PSTs that described learning mathematics as something that came easily to them and therefore felt confident in teaching, expressed a shift in their pedagogical beliefs. Evidence of this shift was apparent in reflections stating that teachers must allow opportunities to share their thinking, use manipulatives regularly, make learning math fun, and not make students race to get right answers. Also, several students focused on communicating mathematical understandings by writing, "kids need time to talk about math. . . math is not just numbers, it is language, too".
Most interesting was the focus that PSTs placed on helping their future students form positive attitudes about mathematics as explicit part of their future practice -- as if in acknowledgement of the strong hold their attitude and beliefs has had on their perceived ability until now. For instance, students wrote about, "encouraging students to love math and be confident", and "creating positive and safe learning environments for all students to be successful", and lastly, "I finally understand why I hated math as a child, and it was not my fault". The

message from PSTs in postcourse reflections was that knowledgeable, confident, positive mathematics teachers create similarly prepared students.

Discussion

The widespread adoption of the Core Standards provides an opportunity for future teachers of mathematics to have a systemic and global impact on the improvement of mathematics education (NCTM, 2014). To successfully implement these standards, future mathematics teachers must promote a "foundation for the development of more rigorous, focused, and coherent mathematics curricula, instruction, and assessments that promote conceptual understanding and reasoning as well as skill fluency" (NCTM, 2014, p. 1). Challenges exist in overcoming PSTs beliefs, however, that are grounded in previous experiences, which often contradict the teaching practice necessary to accomplish this shift in practice (Burns, 2007; Dede & Karakuş, 2014; Kajander, 2010).

The results of this study demonstrate how teacher education programs can find opportunities in methods courses to extend PST's mathematical understandings, as well as influence PSTs personal beliefs and intended future practice. Rather than perpetuating the belief that mathematics is a fragmented and disconnected process of repetitious skills, this research demonstrates how teacher education programs can guide PSTs toward more comprehensive knowledge and conceptual understanding for mathematical concepts. This study further articulated an intentional approach to mathematics methods courses that engages students not only with traditional methods, but with authentic experiences that redefine understandings. This may allow PSTs to connect this new knowledge with previous knowledge and experiences, and then form new links and different mental structures (Reys, Linquist, Lambdin, Smith, & Suydam, 2009). This research further demonstrates the prevalence of a background inundated with traditional models of teaching mathematics (Andrew, 2007) and pervasive anxiety, and the ability to challenge PSTs in a way that promotes conceptual mathematical understandings as well as a revised perspective on future teaching of mathematics.

Although the research uncovering elements of effective teaching in mathematics has been significant over the last twenty years, coursework preparing future teachers may reflect general elementary mathematics teaching methods, without a focused attention to the mathematical concepts, PSTs existing beliefs, or reform based methodology. This research revealed that very few PSTs in this sample have had the experience as a learner in the constructivist practices required to promote advancement in elementary mathematics instruction reform, and even those who believed they were "good at math" expressed experiences with learning mathematics that was void of the constructivist approach best suited to implement the Core Standards.

"There is a strong tendency for novice teachers, once they have entered the profession, to revert to their default model of teaching as they were taught" (Borg, 2004, p. 275). The results of this study provoke reflection about mathematics methods course design. Understanding PST belief structures is essential for educators who attempt to both inform and transform future teaching practice (Grossman, Hammerness, & McDonald, 2009). Data from this study shows that with intentional design in a mathematics methods course, PSTs with self perceived low efficacy, a narrow scope of teaching methodology, and personal epistemologies that contradict current day reform mathematics are capable of reflecting critically and transforming these problematic perspectives. The insights gained through this research are encouraging for teacher educators who wish to provide PSTs with the skills and dispositions necessary to implement the rigorous Core Standards. The findings could be used in further studies to build the capacity of research on teacher effectiveness in the critical area of teaching elementary mathematics (National Council of Teacher Quality, 2009).

According to a report from the United States Department of Education (2008), studies on educational practices are weak in development. Within the large number of studies done on effective teaching and student learning, there are limited amounts of data on how teacher preparation programs are addressing the demands of the Core Standards in Mathematics and the shift required in pedagogical approaches. This research sought to contribute to this gap by examining the influences on PSTs and their beliefs about teaching mathematical content and pedagogical skills. Given the clear links in the literature between PST beliefs, self-efficacy, and instructional choice, this study lends credence to further exploration of methods course design in teacher education.

Limitations and Recommendations

This study is limited by the mostly homogeneous sample of preservice teachers at each institution. Both classes had a disproportionate number of female students, with only 4 males in the 57 total participants. Additionally, course instructors did not have the opportunity to observe PSTs teaching practice in the field to observe for transference into practice, as that was not a requirement of this course. The authors of this study recommend further research in this field of inquiry, especially that which follows PSTs into teaching practice. This research can only speculate upon future pedagogical decisions made in the elementary mathematics classroom. The authors encourage additional research examining PSTs beliefs and ways in which teacher education programs can intentionally make efforts to influence shifts in existing beliefs that may be contrary to best practice. Addressing the gap between teaching theory and classroom practice is an ongoing focus for teacher education programs, and this research offers an approach that may contribute to promoting mathematics reform in effective teaching practice and student achievement.

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Author Information

Karim Medico Letwinsky
Wilkes University
Wilkes-Barre, PA, USA
Contact e-mail: *Karim.letwinsky@wilkes.edu*

Monica Cavender
Quinnipiac University
Hamden, CT, USA