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The Influence of a Reform-Based Mathematics Methods Course on Preservice Teachers' Beliefs

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Beliefs about teaching mathematics and urban students' ability to learn mathematics are often overlooked in the discourse on highly qualified teachers. Altering teacher experiences has the potential to change their beliefs. It was found in this qualitative case study that preservice teachers' beliefs about teaching mathematics to urban students were changed after teachers taught brief sample lessons to their peers and watched video episodes of quality teaching. These findings suggest preservice teacher beliefs can be positively changed after taking reform-based mathematics methods courses. Additional studies are needed to determine if these changes can be sustained during teacher induction.

Keywords: *mathematics, teacher beliefs, urban education*

Introduction

In recent years, the preparation of mathematics teachers has become an increasingly important area of interest to mathematics educators and policymakers. In the United States, the National Science Foundation (2005) and the National Research Council (2000) agree that reforming teacher preparation in postsecondary institutions is a central factor in enhancing the capacity to improve mathematics education for all students. The conversation about highly qualified teachers is generally focused on knowledge of content (Ball, Hill, & Bass, 2005).; however, an important factor that is often overlooked in the discourse on highly qualified teachers is beliefs about teaching mathematics and students' ability to learn mathematics (Charalambous, Panaoura, & Philippou, 2009). For preservice teachers who enter the teaching profession in urban settings, these beliefs are seminal to student success.

This study took place in a reform-based mathematics methods course. Reform-based mathematics teaching in this study is characterized by redefining teachers and student classroom roles, including enacting a set of practices that creates environments in which students discuss and reflect upon their learning, and connecting content to students' everyday mathematics experiences (National Council of Teachers of Mathematics [NCTM], 2000; Sherin, 2002). Teachers must learn to productively support and extend individual students' reasoning and to guide mathematical

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discussions that build collective understanding of both the mathematics content and the nature of mathematical thinking if they choose to engage in reform-based mathematics teaching. Teaching for understanding requires approaching instruction from the perspective of the learner, and students must learn to develop mathematical arguments, make conjectures, provide explanations, clarify assumptions, investigate, and seek to refute with counterexamples. In order to lead authentic problem-solving activities, preservice teachers need opportunities to engage in meaningful problem solving themselves and to explore various problem solving approaches, representations, and connections to appreciate mathematics problems as more than simply "word problems" or applications of known mathematics procedures.

Building on students' informal knowledge is a viable way to develop their mathematical understanding (Fennema, Franke, Carpenter, & Carey, 1993). Because students bring different forms and kinds of informal knowledge with them to school, based on their experiences, teachers must develop culturally appropriate strategies to capitalize on students' informal knowledge (Leonard, 2007; Banks, 1993). Chronic underachievement in mathematics among particular groups of students can be understood as missed opportunities for educators to make meaningful connections between the culture of the students and the mathematics content.

Changes in classroom roles and approaches to teaching mathematics frequently challenge preservice teachers' beliefs about mathematics. According to Pajares (1992), "All teachers hold beliefs, however defined and labeled, about their work, their students, their subject matter, and their roles and responsibilities" (p. 314). Pajares argued, however, that beliefs are diffuse and difficult to operationalize. Beliefs are defined for this study as existential presumptions, which are the personal truths everyone holds and are characterized by making judgments and evaluations about phenomena, subject matter, and individuals (Abelson, 1979; Pajares, 1992). More specifically, the beliefs in this study involved the combination of preservice teacher beliefs about the best practices of teaching, knowledge of mathematics, value of mathematics, effect of educational histories on teachers, confidence in mathematical and teaching abilities, and teaching efficacy. The combination of these factors constitutes the teachers' educational belief systems.

Individual beliefs endure even when they are contradicted by reason, evidence, or experience (Pajares, 1992). Lortie (1975) claims beliefs about teaching are developed at early ages and are well-established before students enter college. Nevertheless, Pajares (1992) argued behavior is the result of beliefs that have been filtered by experience. Thus, altering preservice teachers' experiences has the potential to change their beliefs. Further, Enterline, Cochran-Smith, Ludlow, and Mitescu (2008) found evidence of more positive teacher beliefs toward teaching for social justice at the end of a teacher preparation program compared to at the beginning of the program.

The purpose of this qualitative case study was to report on changes in preservice teachers' beliefs after taking a reform-based mathematics methods course. The research question that guided this study was, "How do preservice teachers' beliefs compare before and after taking a reform-based mathematics course?"

Theoretical Framework

This research study is framed by sociocultural theory (Vygotsky, 1987), which purports that collective and individual processes are directly related (Cobb & Yackel, 1996). In this context, an instructor guides learning and enculturation as students are taught the skills and concepts needed to function and become productive citizens in society (Vygotsky, 1987). In this perspective, learning

is understood as a process of "enculturation into a community of practice" (Cobb, 1994, p. 13). As a community of practice, a set of ideas was developed to strengthen preservice teachers' mathematics identity. Mathematics identity is one's belief about "(a) ability to do mathematics, (b) the significance of mathematical knowledge, (c) the opportunities and barriers to enter mathematics fields, and (d) the motivation and persistence needed to obtain mathematics knowledge" (Martin, 2000, p. 19). Many of the preservice teachers we have taught had negative experiences with many of their own mathematics teachers and/or the content. The premise for this study is most of these preservice teachers did not fully understand the mathematics and were fearful of teaching it. Teacher "identity and awareness both mediate action and pedagogy" (Gonzalez, 2009, p. 23). By attending to identity, there is focus on preservice teachers' beliefs about teaching and learning mathematics and their roles as teachers of mathematics (Gonzalez, 2009). Further, educational beliefs can influence teacher practices and decision-making in the classroom (Pajares, 1992; Thompson, 1992).

Methodology

The college of education where the study took place is situated in a large city in the northeastern United States. The number of students enrolled in the college is approximately 2,100 per year. In their junior year, prospective teachers admitted to the early childhood/elementary certification program are enrolled in practicum and methods courses. Each practicum is taken in conjunction with specific methods courses in the core curriculum (i.e., reading/language arts and social studies methods and practicum, as well as mathematics and science methods and practicum). Practicum students are assigned to urban K–8 classrooms where they team-teach in groups of four 2 days a week.

Description of Participants

The teacher-researcher for this qualitative case study taught a section of mathematics methods with 25 preservice teacher participants. The preservice teachers were simultaneously enrolled in a science methods course and a mathematics/science practicum. Prior to participating in this study, the teacher-researcher had taught the undergraduate mathematics methods course more than 12 semesters and had previously taught mathematics at three different early childhood/elementary schools for a total of 13 years.

Description of Methods Course

Using reform-based strategies with students required some preservice teachers to make a shift in their educational beliefs (Pajares, 1992). As a result, the teacher-researcher designed the course to attend to the content and pedagogical needs of preservice teachers and to confront their own students' extant beliefs. The mathematics methods course was aligned with the NCTM *Standards* (NCTM, 2000), and each class session began with a problem of the day that was related to the content or process standards focused on during that session. Short PowerPoint presentations were posted on Blackboard and presented in class to promote discussion of the methods raised in the primary text, which was written by Cathcart, Pothier, Vance, and Bezuk (2006). Blackboard is an interactive software program that can be used by instructors and students to access a common set of materials and resources. During these presentations, the teacher-researcher used manipulatives (e.g., place value blocks, two-color counters, spinners, and dice), authentic tasks (e.g., calculating percentages using real menus from restaurants), and small group work to illustrate the mathematics concepts under discussion. The focus on concepts was to help preservice teachers understand

mathematics in more depth. For example, place value blocks in bases four and five were used to help preservice teachers better understand and appreciate the base-10 place value system and numeration.

Use of Video

In the methods class, videos were also used to enhance preservice teachers' content knowledge and pedagogy. *Integrating Mathematics and Pedagogy*, a CD-ROM accompanying the text by Cathcart and colleagues (2006), provided preservice teachers with a number of video clips and vignettes that presented children's mathematics strategies. In addition, videos from the *Kay Toliver Files* (Foundations for Advancement in Science and Education Productions [FASE], 1994) were presented to preservice teachers. Thus, preservice teachers in the methods courses had the opportunity to learn how to implement mathematics instruction vicariously by watching the *Kay Toliver Files* and experiencing the teacher researcher's pedagogical practices (Yoon et al., 2006).

Microteaching

During the semester, preservice teachers were also provided with opportunities to experience mastery (Bandura, 1986). Each preservice teacher presented a microteaching lesson to demonstrate what was learned from the methods course. Microteaching consisted of teaching a short 15- to 20-minute lesson with a partner. These lessons provided preservice teachers with an opportunity to model teaching a specific mathematics concept or skill to peers, and preservice teachers had the opportunity to present lessons to actual students during a practicum. Sometimes preservice teachers taught the same lesson as the one they presented for microteaching in the methods course during the practicum. Thus, preservice teachers were able to receive feedback from the teacher-researcher and peers, learn by doing, and reflect upon their practices (Lowery, 2002).

Reflective Journals

Goodman (1988) suggested researchers can analyze teachers' beliefs by making inferences from their belief statements. Examination of these belief statements is critical to understanding preservice teachers' beliefs about teaching and learning mathematics. The reflective process provides opportunities for preservice teachers to examine their personal experiences and beliefs that influence their view of teaching (Mewborn, 1999). Over the course of the semester, preservice teachers made 8 to 10 hand-written entries in their journals. The first assignment in the methods courses was for preservice teachers to write about their history and past experiences with mathematics. In their final entry, they were asked to reflect on what they believed they learned during the semester. For the other entries, preservice teachers were able to reflect on any content or discussion that occurred in the methods course or the practicum. This decision was made so that the most influential features of the course would emerge. The handwritten journals were collected and returned three times to ensure accountability and provide feedback. Using the constant-comparison method (Glaser & Strauss, 1967), preservice teachers' journals were analyzed to note changes or lack of change in their belief systems. Preservice teachers' belief statements were coded and categorized based on the data that emerged. The journals provided rich narratives about the influence of the reform-based course on preservice teachers' educational beliefs. Considering the large number of journal entries, it was preferable to use only a limited number of student journals, and hence 9 student journals were randomly selected from 25 students.

Results

Nine participants using pseudonyms (Joy, Mandy, Erin, Edith, Jamie, Yvette, Cathy, Joan, and Anita) were randomly selected for qualitative analysis. We collected preservice teachers' responses to queries about their mathematics backgrounds and beliefs at the beginning of the course and reflections on their beliefs and practices at the end of the course.

Our analysis of the preservice teacher journals revealed eight factors related to educational beliefs that emerged in the case study participants' journals at the beginning of the reform-based methods course:

- Beliefs (i.e., judgment/evaluation)
- Values
- Educational history
- Affective states
- Verbal persuasion
- Vicarious experiences
- Mastery experiences
- Content knowledge

Three additional factors, for a total of 11, related to educational beliefs emerged from case study participants' journals at the end of the reform-based methods course:

- New knowledge
- Personal teaching efficacy (i.e., self-efficacy)
- Teacher efficacy (i.e., outcome expectancy)

We summarize our findings for the comparison and contrast of educational beliefs at the beginning and end of the course, as well as additional preserve teachers' beliefs at the end of the course, in the following sections. We briefly present a summary of all 11 factors in the Results section, and then present synthesis of the data in the Discussion section.

Comparison and Contrast of Educational Beliefs at Beginning and End of Course

Belief Statements

Our analysis revealed that belief statements (i.e., judgments/evaluations) were made about mathematics as a subject domain, mathematics teaching, and/or learning in all nine cases at the beginning of the methods course:

> *I am a strong believer that children will learn better through inquiry and active learning.* (Mandy)
>
> *Many people dislike mathematics.* (Yvette)

In comparison, preservice teachers made beliefs statements in all nine cases at the end of the course just as they did at the beginning; however, the belief statements were more prescriptive at the end of the course:

> *If math teachers would stop forcing students to memorize facts and lecturing, and instead add hands-on activities, such as the ones we presented in class,*

> *math would be a more enjoyable subject. If the children enjoy it, they will perform better.* (Anita)

In contrast, one belief statement also revealed teacher bias:

> *My practicum classroom served several purposes for me this semester. First, it made me aware of a painstakingly horrible truth—public schools are so far behind in math. This point was made clear by the fact that seventh graders could not complete simple math facts without the use of their fingers or calculator. Another disturbing reality was that the class had yet to master their multiplication tables and seemed endlessly stuck on fractions, decimals, and percents. Each of these points directly conflicts with my own Catholic school education.* (Cathy)

These data concurred with findings that teacher beliefs are related to classroom behaviors (Hart, 2002; Pajares, 1992). These belief statements led us to make inferences about these two preservice teachers' classroom behaviors. In Cathy's case, her beliefs about public students' mathematics skills may influence her to focus on drill and practice in the mathematics classroom, whereas Anita's beliefs may influence her to focus more on inquiry. Thus, it was important to understand preservice teachers' beliefs in order to address their potential classroom behaviors.

Value

Yvette was the only preservice teacher to make a value statement at the beginning of the course:

> *I believe that math is very important because it is used in our everyday lives.*

Yvette's statement, however, in conjunction with the ones highlighted earlier, revealed that some preservice teachers can dislike mathematics and still value it. Likewise, Cathy was the only one to refer to values at the end of the course:

> *I still maintain the belief that math is essential and is everywhere.*

What is not clear to us from either of the journal entries, however, is how these two preservice teachers might go about helping students to value mathematics.

Educational History

In eight cases (all but Joy), preservice teachers included statements about educational history at the beginning of the course. Statements about educational history were prompted by the teacher-researcher's request that preservice teachers describe how their educational backgrounds influenced their learning of mathematics in their initial journal entry. For example, Jamie stated:

> *Math was one of those subjects that I used to love. My worst experiences were in 3rd grade and 10th grade algebra.*

We find the data in Jamie's case, as well as several others, are consistent with the findings of Charalambous, Philippou, and Kyriakides (2008) and Swars, Hart, Smith, Smith, and Tolar (2007), which suggested that educational histories influence teacher belief systems about mathematics content.

Joan's was the only case to refer to educational history at the end of the course:

> *I was the student who just needed an example from the teacher in order to learn how to use a math concept. I never used interesting materials with math, which may be the reason I never enjoyed math class. Some students need to learn math with a hands-on approach.*

What is compelling to us about Joan's statement, however, is she did not allow her educational history to hinder the students' needs. She realized that all students do not learn mathematics in the same way; yet it is unclear whether this was a modified, new, or sustained belief.

Affective States

Preservice teachers also made statements about their affective states in all nine cases at the beginning of the course; however, the affective statements of preservice teachers who were immigrants in the United States provided interesting caveats:

> *I used to attend school in Bahrain. I had to memorize everything. I remember disliking having to memorize the times tables and doing long division.* (Joy)

> *I really don't like mathematics. Many people dislike math. I don't like a subject where there can only be one right answer to a solution. I am a foreigner in the United States and have been in this country for 8 years. My country is now called Ukraine, but my native tongue is Russian. Coming from a place where mathematics was the key to a successful education, I can honestly say that in my former country math was something that you had to know how to do or else.* (Yvette)

These two cases illustrate to us that emphasis on memorization could have a negative impact on students' belief systems as they relate to learning mathematics regardless of their country of origin.

In contrast, affective statements were made about mathematics and mathematics teaching in six cases (Joy, Erin, Edith, Jamie, Yvette, and Joan) at the end of the course. In three of these cases, beliefs about mathematics changed as a result of the course:

> *This class has opened my eyes to see that math can be fun.* (Joy)

> *I am happy to say that I no longer hate math, but I am intrigued at the endless possibilities I have in teaching math.* (Erin)

> *Since taking this course, my feelings about math have changed. The practicum had a lot to do with this because I learned how to make math lessons iterative and engaging for students. In this course I saw how important it is to use manipulatives in math lessons. I have never really liked math.* (Joan)

While these statements are encouraging, Pajares (1992) reminds us that newly acquired beliefs are vulnerable, and Joan's statement illustrates this vulnerability. On one side, she states that her beliefs had changed, and on the other side she admitted she "never really liked math." Yet, it was Joan who realized that her dislike for mathematics may have been connected to how it was presented to her and not mathematics itself. Joan's mixed message revealed the importance of field experiences in improving preservice teachers' negative beliefs toward mathematics (Hart, 2002).

Verbal Persuasion

Verbal persuasion was inferred from statements made in three cases (Cathy, Joan, and Anita) at the beginning of the course. One example of verbal persuasion follows:

> *My teacher told my parents that I was a "wiz at math."* (Joan)

No statements were made in the journals that could be classified as verbal persuasion at the end of the course.

Vicarious Experiences

Mandy was the only case study participant to include statements about vicarious experiences at the beginning of the course. She referenced Kay Toliver after watching *Good Morning Ms. Toliver* (FASE, 1994) on the first day of class.

> *I never learned math like that and saw [in Kay Toliver video] how much the kids were learning while they were having fun and connecting it to the real world.*

In contrast, vicarious experiences were mentioned in four cases at the end of the course (Joy, Mandy, Erin, and Edith). In two cases (Mandy and Erin), the influence of Kay Toliver videos on preservice teachers' beliefs was evident. These statements support Yoon and colleagues' (2006) contention that teachers' beliefs and efficacy can be improved with videos. Interestingly, all four of these preservice teachers also mentioned the positive impact that peer teaching had on their beliefs and efficacy. For Edith, peers had a profound impact on her beliefs:

> *Another part of this semester that I truly enjoyed was the learning community we developed. Everyone who was in my practicum was also in science and math methods courses. This was beneficial because we truly got to know and learn from our peers.*

Edith's comment also provided a rather unique finding that suggests the importance of establishing a learning community. One's peers can provide the support needed to sustain newly acquired knowledge and beliefs. Joy's case pinpoints the importance of peer modeling on her beliefs:

> *Having my classmates teach lessons also added to my collection of lessons that I could teach to my future students.*

This is also a unique finding that is not prevalent in the literature. Microteaching was a part of the mathematics methods course because the teacher-researcher did not believe she could evaluate preservice teachers' pedagogy without seeing actual practice. The influence of peer teaching was a powerful finding that was not expected, and it reinforced the importance of a positive learning community (Lave & Wenger, 1991; Lowery, 2002).

Mastery Experiences

In the beginning of the course, Mandy was the only case study participant to refer to mastery experiences:

> *Being that math is my favorite subject to teach, I have already experimented with math lessons. For example, during a multiplication review, I had*

> *different centers with different games (multiplication bingo, dice, and flash cards). I have also visited many math websites and got some good ideas.*

Interestingly, Mandy connected the vicarious experience provided by watching the Kay Toliver video (FASE, 1994) to her educational history and the mastery experience to her affective state. In Mandy's case, the influence of the Kay Toliver videos enhanced the influence of her educational history. The visual images of students learning and having fun in the mathematics classroom was enough to inspire Mandy to try some ideas of her own. These statements support Pajares's (1992) claim that teacher beliefs about best practices can be changed and Bandura's (1997) contention that affective states influence efficacy.

Likewise, mastery experiences were mentioned only in one of the nine cases at the end of the course:

> *I realize from my practicum that my students loved to make music and dance, so I came up with a way to use graphs to plot their dance moves. I then reflected on how my students loved treasure hunts and solving mysteries and put that all together to come up with the game: On our way to the treasure spot. Though there was a lot of work that had to go into this lesson, I loved it because it fun and involved learning that was meaningful for my students.* (Jamie)

Jamie's willingness to develop an authentic task to teach coordinate graphing provided her students with high-quality mathematics teaching. In order for such practices to be sustained, teachers' beliefs must be reinforced with sufficient practice (i.e., time and use; Pajares, 1992).

Content Knowledge

Finally, belief statements made in these cases provided information about these preservice teachers' content knowledge before taking the reform-based course. Content knowledge statements, both implicit and explicit, were evident in five cases (Joy, Erin, Cathy, Joan, and Anita), such as the statements below:

> *Math has always been my poorest subject.* (Joy)

> *I was becoming familiar with the multiplication tables. Upon entering school, I found myself ahead of the other children. My interest in math did not wane.* (Cathy)

Joy's statement about content is also a belief statement or judgment about her mathematics ability in relation to other subjects. Cathy's statement suggested a relationship between content knowledge and interest in mathematics, which is not prevalent in the literature. Research studies that explore the link between content knowledge and interest are needed to shed more insight on these two constructs.

At the end of the course, preservice teachers made references to content in four cases (Joy, Erin, Joan, and Yvette). Joy's belief statement was related to the examination for state certification (i.e., Praxis examination) as well as a mathematics content test students took in the methods class:

> *This class has been helpful for me because I have been practicing for the Praxis. If I were to take the content test again, I am confident that I would pass.*

Additional Preservice Teachers' Beliefs at the End of the Course

We found that three additional factors related to mathematics teaching and/or learning emerged from the cases at the end of the course: acquisition of new knowledge, personal teaching efficacy, and student outcomes.

Acquisition of New Knowledge

Acquisition of new knowledge was evident in five cases (Joy, Erin, Yvette, Joan, and Anita). A few examples of these statements follow:

> *I have learned so much through this course in the way of teaching theories, strategies, problem solving variations, teaching materials, and numerous math processes.* (Erin)

> *Honestly, I do not know how I would teach math without this course. Throughout the semester, I have seen that it is not the actual content but the way you present it that really matters. I have also learned that there are many different ways in which children learn best. Some children perform better in a more structured environment, whereas others prefer a less structured environment.* (Yvette)

> *I have learned some important things in this class, such as memorization is not the goal of math. As a teacher I want students to be able to critically think and come up with solutions to everyday problems.* (Anita)

These data imply for us that the reform-based mathematics methods course influenced preservice teachers' learning in a myriad of ways. It is particularly compelling that Yvette realized that different students had different needs.

Personal Teaching Efficacy

Preservice teachers also made comments about confidence and preparedness to teach mathematics in five cases (Mandy, Erin, Edith, Jamie, and Cathy).

> *I feel that the math/science practicum has prepared me to teach, particularly in the areas of math.* (Jamie)

> *Through this course and my math/science practicum, I have much more confidence in my teaching abilities.* (Erin)

Outcome Expectancy

Anita's case was the only one of the nine to address student outcomes. Moreover, her comment specified what she believed to be the relationship between content and student outcomes:

> *Knowing how to process information or manipulate facts to come up with sound solutions can increase one's achievement.*

Student outcomes and achievement variables also shaped teacher beliefs (Ernest, 1989).

Discussion

The results of our study support several findings. Experiences reported in the class illustrated that the microteaching of peers, a salient part of the reform-based course, had a profound influence on preservice teachers' beliefs, which is unique because it is absent from the literature on preservice teachers' beliefs. Another element of the course that influenced preservice teachers' efficacy was the Kay Toliver videos (FASE, 1994). The belief statements confirm that videos can provide preservice teachers with the vicarious experiences needed to change their beliefs. These findings are in contrast to findings from Reeder, Utley, and Cassel (2009), who found that beliefs were unaffected by a mathematics methods course.

At the end of the semester, preservice teachers expressed stronger efficacy beliefs in their abilities to teach well. For example, at the end of the course one preservice teacher said, "I have much more confidence in my teaching abilities." Palmer (2006) claimed that several factors such as hands-on activities, group investigations, relation of concepts to the real world, and microteaching have the potential to increase efficacy in a reformed-based course. While the literature suggests that mastery experiences are also important, they were only mentioned by one student at the beginning and one student at the end of the course, which may have more to do with the writing prompts. This finding suggests future studies should ask preservice teachers to reflect on practicum more specifically in mathematics methods courses. Further, future studies should examine disparities between belief statements and actual classroom practices.

We learned that practices such as those modeled in reform-based mathematics methods courses led to positive changes in beliefs. Based on the results, it appears that preservice teachers experienced a change in their mathematical identity, which affected their roles as mathematics teachers (Gonzalez, 2009; Martin, 2000) and can be seen in the teachers' increased confidence to learn and teach mathematics. We question, however, whether or not this will be sustained throughout teacher induction.

Conclusion

Hill, Rowan, and Ball (2005) claimed that reform-based mathematics instruction produces high-quality early childhood/elementary teachers of urban students. Pedagogy in the reform-based methods course described in this study engaged preservice teachers in inquiry-based activities in order to enhance their conceptual knowledge and mathematical understanding. Future studies should examine the relationship between increased content knowledge and beliefs toward mathematics. Improving these constructs for beginning teachers who choose to work with diverse populations should translate into improved mathematics learning and achievement among poor and urban students if teachers are also attentive to these students' learning styles and cultures (Leonard, 2007; Martin, 2007). The results of this study are promising; however, additional studies are needed that span practices learned in teacher education programs to practices actually performed during teacher induction to determine whether beliefs toward mathematics learned in reformed-based mathematics methods courses are sustained across time.

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