Assessment Grant Final Report

Project Title: Assessing Preservice Teachers’ Math Academic Achievement, Growth Mindset and Self-Efficacy

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In this final report, Fu and Kartal provide a description of the project, a summary of the results, conclusions drawn from the project, contribution of the work to assessment at the UW-Whitewater, challenges encountered, future plans, and the conference proposal as the deliverable.

Project Description

This project intended to investigate the growth in preservice teachers’ mindset and self-efficacy in teaching mathematics through a math methods course, ELEMMID 425. It further investigated the bivariate relation between their mindset, self-efficacy, and academic achievement in ELEMMID 425, i.e., teaching mathematics in the elementary and middle grades. The proposed project was guided by the following research questions/objectives:

1) To what extent does preservice teachers develop a growth mindset and self-efficacy in teaching and learning of mathematics through ELEMMID 425?

2) How does the growth, if at all, in preservice teachers’ mindset and self-efficacy relate to their academic achievement in ELEMMID 425?

3) What are the aspects of ELEMMID 425, if at all, that help preservice teachers develop a growth mindset and improve self-efficacy?

Fu and Kartal worked with preservice teachers who were enrolled in multiple sections of ELEMMID 425, and were volunteered to participate in the study. In the fall of 2018, the researchers administered pre- and post-tests at the first and last day of the course to measure the change in preservice teachers’ mindset and self-efficacy in teaching of mathematics. The bivariate correlational relationship between preservice teachers’ academic achievement in the course, the change in their mindset, and the change in their self-efficacy were explored. Students’ academic achievements were measured through three major assignments in the course. For the first assignment, students designed a high-level mathematics task for their future students, anticipated variety of student approaches, discuss similarities and differences between the approaches, and planned for questions to ask students in order to help them through the problem-solving process without revealing the answer, or to probe into their reasoning process. For the second assignment, they analyzed multiple student works for the same task, elicited and used student’s understanding, and planned for future instruction. For the third assignment,
preservice teachers wrote and implemented detailed lesson plans which employed student-centered teaching style and supported active learning. In order to explore what particular topics and activities in ELEMMID 425 helped them grow their mindset and efficacy for teaching mathematics, students responded to two open ended questions at the end of the course through a written survey.

**Summary of the Results**

In summary, the findings of the study indicated that preservice teachers improved their self-efficacy in teaching and learning of math in ELEMMID 425, statistically significantly, yet they did not improve significantly on the general implicit theories of intelligent scale. In other words, they entered math methods course barely disagreeing that they had a certain amount of intelligence that cannot be changed much, and they left the course barely agreeing that their intelligence amount cannot be changed. The findings of the study further revealed that there is no statistically significant relation between mindset, self-efficacy, and academic achievement in math methods course. Although, preservice teachers’ beliefs about general implicit theories of intelligence did not change much through the math methods course, their self-efficacy and mindset in teaching mathematics grew through the course, as evidenced in their responses to open ended questions. The results informed the authors that learning about variety of inductive teaching styles of mathematics, learning and practicing variety of differentiation for inclusion techniques, and learning to support productive struggle in mathematics classroom most helped the preservice teachers grow their mindset in teaching mathematics. Planning, writing, and implementing an inductive style lesson, and going through struggle in class, as well as learning to support productive struggle through asking questions helped them improve their self-efficacy in teaching mathematics.

**Conclusions Drawn from the Project**

As described, the study assessed students’ learning outcomes in teaching mathematics, growth mindset, and math teaching efficacy. The authors would take full advantage of the assessment results to strengthen the current course in the Elementary Education Program. The study results will also be shared with instructors of MATH 148 and MATH 149, which are the prerequisites of ELEMMID 425. Interdepartmental collaborations can be established to nurture preservice teachers’ growth mindset and math teaching efficacy early on while taking the math courses.

**Project Contribution**

The project contributed to the UW-Whitewater assessment by shedding light on promoting a learning environment that encourages a growth mindset culture. Many preservice teachers have a fixed-mindset about math learning and possess low self-efficacy in teaching math to elementary and middle school students (Bates, Latham, & Kim, 2013). Given that mindset and self-efficacy can significantly influence preservice teachers’ math academic
achievement and future teaching performance (Huangfu, 2012; Skaalvik & Skaalvik, 2010), the current project plays an essential role in assessing those constructs and strengthening students’ competence and confidence through taking the course.

**Challenges Encountered**

The biggest challenge was to hire qualified student research assistant (RA) since we intended to have two RAs to work with us throughout the project. It did not take us long to find out that not many students were interested in doing research. Among the limited number of students who were interested, a vast majority of them cannot work on the project due to other job responsibilities. We were able to hire one RA during the project and spent a lot of time on training her; however, she only worked with us for a semester and then graduated. Given all the time and efforts to find and train RAs, Fu and Kartal decided to finish the rest of the project by themselves.

**Future Plans**

Fu and Kartal submitted a proposal to the 2020 American Educational Research Association (AERA) Conference. If the proposal is accepted, they will present at the conference. In addition, they will work towards developing and revising a manuscript to be submitted to a journal related to mathematics teacher education.

**Conference Proposal as the Deliverable**

Please see the attached conference proposal (pp. 4-11) which was submitted to the 2020 AERA conference.
Purpose of the Study

Research shows that elementary education majors have the highest rate of mathematics anxiety of any college major (e.g., Bursal & Paznokas, 2006; Gresham, 2007; Hall & Ponton, 2005; Harper & Daane, 1998; Hembree, 1990; Kelly & Tomhave, 1985; Vinson, 2001); and preservice teachers’ (PTs) mathematics anxiety is negatively correlated with their self-efficacy for teaching mathematics (Bursal & Paznokas, 2006; Brady & Bowd, 2005; Gresham, 2008; Swars, Daane, & Giesen, 2006). Many preservice elementary teachers have a fixed-mindset about mathematics learning and teaching, and possess low self-efficacy in teaching math to elementary and middle school students (Bates, Latham, & Kim, 2013). Given that mindset and self-efficacy can significantly influence PTs’ future teaching performance (Huangfu, 2012; Skaalvik & Skaalvik, 2010), it is critically important to help PTs to develop a high self-efficacy and a growth-mindset for teaching math throughout teacher preparation programs.

Specifically, this study investigates the growth in PTs’ self-efficacy in teaching mathematics through a math methods course, and reveals the best practices that help them develop self-efficacy and growth-mindset in teaching mathematics. The study is guided by the following two research questions: To what extent does PTs develop a self-efficacy in teaching of mathematics through a mathematics methods course? What are the best practices that help PTs develop self-efficacy and growth-mindset in teaching of mathematics?

Literature Review

Self-efficacy in teaching mathematics or mathematics teaching efficacy is defined as one’s belief in their ability to teach mathematics effectively (Enochs et al. 2000). Researchers have widely studied the effects of teachers’ self-efficacy on teaching and learning. Abundant literature has corroborated the influence of efficacy beliefs on teachers’ burnout, job satisfaction, and instructional practices. Particularly, teachers with lower self-efficacy beliefs were more likely to suffer from emotional exhaustion and depersonalization, dissatisfy with their current work; they were also less likely to apply instructional strategies that engaged students in learning (Huangfu, 2012; Maslach, Jackson, & Leiter, 1996; Viel-Ruma, Houchins, Jolivette, & Benson, 2010), and hence teacher self-efficacy beliefs have been found to be related to students’ academic achievement. For instance, Maguire (2011) reported positive correlation between 12 teachers’ self-efficacy beliefs and 535 students’ math scores in a state-mandated assessment. Khan’s (2012) study also espoused the impact of teacher efficacy on student learning outcomes in both English and mathematics.

Apart from its effects on teaching and student achievement, studies investigated the link between PTs’ mathematics self-efficacy, mathematics teaching efficacy, and mathematical performance (e.g., Bates, et al., 2011; Bursal & Paznokas, 2006; Skaalvik & Skaalvik, 2006). In addition, a high self-efficacy is positively correlated to a growth-mindset (Palazzolo, 2016). Dweck (2008) describes growth-mindset in teaching as a mindset that asks “How can I teach them?” and “How will they learn best?” instead of asking “Can I teach them?” and “Can they learn?”—which are indicators of a fixed-mindset in teaching. The effects of fixed and growth-mindsets have been investigated in numerous educational research studies in relation to increased self-efficacy, persistence, and motivation, and better academic achievement (e.g., Blackwell, Trzesniewski, & Dweck, 2007; Bedford, 2017; Esparza, Shumow, & Schmidt, 2014; Hochanadel
Research found that growth-mindset intervention is especially impactful on student achievement in particular subjects such as science and mathematics (e.g., Aronson, Fried, & Good, 2002; Blackwell et al., 2007; Grant & Dweck, 2003). Few studies investigated the role of particular teaching approaches and learning skills in fostering student’s growth-mindset (e.g., Laurian-Fitzgerald, 2016; Rissanen, Kuusisto, Tuominen, & Tirri, 2019), and the impact of the training on sustained change to teacher mindset and practice (e.g., Seaton, 2018). For example, Rissanen et al. conducted a case study of an experienced mixed-mindset classroom teacher, and presented core features of growth-mindset pedagogy actualized in the teacher. They observed that the teacher supported student’s individual learning processes, promoted mastery orientation, and fostered process-focused thinking in her students. They also observed critical instances where the influence of the teachers’ fixed-mindset became apparent. The critical points they identified in teacher’s practice were: lack of persistence in teaching some of her students, relying on the motivating power of success and protecting some of her students from challenges instead of teaching them how to cope with mistakes and failures, and implementing trait-focused pedagogy for academically competent students. The best practices that support PTs to increase self-efficacy, and to develop a growth-mindset for teaching mathematics remain understudied.

Methods

Participants of this study are 52 elementary PTs, who were enrolled in math methods course in a teacher preparation program. The Self-Efficacy for Teaching Mathematics Instrument (SETMI) (McGee & Wang, 2014) was used to measure PTs’ self-efficacy in teaching mathematics at the beginning and end of the course (see Appendix). At the end of the course work, students were also asked to respond to two open-ended survey questions which helped uncover the best practices in the course that impacted their mindset and efficacy for teaching mathematics. The first survey question was asked to reveal the best practices that helped them develop a growth-mindset in teaching mathematics: Which aspects of math methods course, if at all, helped you develop a mindset that asks “How can I teach them?” and “How will they learn best?” instead of asking “Can I teach them?” and “Can they learn?” The second survey question revealed the best practices that helped them increase self-efficacy for teaching mathematics: Which aspects of math methods course, if at all, helped you develop self-efficacy in teaching mathematics (i.e., belief in your ability to successfully teach mathematics in elementary and middle grades)?

Paired t-tests were conducted to determine the change in PTs’ self-efficacy for teaching mathematics throughout the course. Responses to two open-ended survey questions were coded using constant comparative analysis to identify the best practices in the course that impacted PTs’ mindset and self-efficacy for teaching mathematics.

Results

The results showed that there was a statistically significant difference in their scores for SETMI pre-survey ($M = 3.59, SD = 0.44$) and post-survey ($M = 3.90, SD = 0.40$); $t (51) = -3.368, p < 0.001$.

PTs responses to fist open-ended question indicated that all PTs left the course with an improved growth-mindset in teaching mathematics. 76% of them reported that learning about
inductive ways of teaching mathematics helped them develop a growth-mindset in teaching mathematics. For example, one PT wrote “…learning various inductive teaching models helped change my thinking because it showed me that there are a wide variety of ways to teach the same lesson. Therefore, if a student is not understanding it, I know different ways that I can explain the material to them or different activities. This transferred from can I find the right way to teach them to how can I teach them in a different way if they are not understanding.” Many PTs indicated that they only knew one way of teaching math, which is direct teaching, before coming into the methods class, “…different teaching styles helped me learn all of the different ways students learn. Before this class I always thought of math as a class you use direct teaching for, I wouldn’t have thought to use a method that has students discover the content for themselves.” Another practice that helped them grow their mindset in teaching mathematics was reported as learning variety of differentiation for inclusion techniques. 44% of the PTs explained that learning and practicing variety of inclusion techniques helped them with the mindset that mathematics can be taught to all students. For example, one PT wrote “…information on differentiation helped me with this mindset the most because it really goes back to how can I get all my students to use the same levels of thinking to achieve the same content goals but in ways that will be the most productive to them. It reminds you that equal doesn’t mean equitable. I think the differentiation topics and learning the different strategies, multiple means of engagement, accessibility, and representation really highlights the idea that every concept can be taught in a multiple of ways so that every child has the opportunity to learn.” Another aspect of the course that was found most helpful in growing their mindset was exploring the practice of “support productive struggle” in mathematics classroom. 40% of the PTs explained how the idea of “support productive struggle” helped them grow their mindset. For example, one PT wrote “I really enjoyed the push for the productive struggle, because for most teachers it’s easy to jump in, and leaning that struggle can actually benefit them was eye opening. The hardest part about the struggle is the urge to jump in and help, and by practicing that in this course it helped with finding questions to ask without directly giving them the answer.” Lastly, 40% of the PTs reported that actually engaging in problem solving tasks in class helped them grow their mindset about teaching mathematics. For example, one PT wrote “…I realized that although I had learned how to do these problems in another way, that by working through a problem in a way that a specific student might, I feel I have a better understanding of how they think.”

In response to the second open-ended question, 88% of the PTs reported that learning about inductive teaching styles, comparing inductive teaching style with direct teaching style, and writing and implementing an inductive style lesson plan helped them improve their self-efficacy in teaching mathematics. For example, one PT wrote, “doing the lesson plan in a style that wasn’t direct teaching helped me realize I could successfully teach math. When we first got the assignment I thought it was going to be extremely hard to create a lesson that allow students to discover a math concept without first being told what it was. Once I started to actually create the lesson I realized it’s not as hard as I thought it was and it gave me confidence to produce more lessons like this, and not always use direct teaching for mathematics.” Other PTs wrote, “…getting to practice an inductive style of teaching that is focused on discovery and is student-centered really gave me the confidence that I can actually help all students learn rather than reverting to direct-teaching.” and “Prior to this class, I only had knowledge of the teaching techniques that my own teacher and professors have used throughout my years in school. However, in this course, I learned that many of these techniques and strategies are unproductive, explaining why most of them did not work while I was trying to teach lessons.” 24% of the PTs
reported that learning to support productive struggle through asking questions, as well as themselves experiencing struggle in the course, helped them improve self-efficacy in teaching mathematics. For example, one PT wrote, “…I really like how productive struggle was supported within this classroom. For each of our main assignments, I like that we were encouraged to struggle on our own at first, but then were provided with further feedback before having the opportunity to struggle through the assignments again. If I was not provided with the opportunity to redo the assignments, I honestly would have accepted failure and never went back to change my work. The redo process helped me to discover where I went wrong and forced me to try again, and improved my self-efficacy.”

In summary, the findings of the study indicated that PTs improved, statistically significantly, their self-efficacy in teaching and learning of math in math methods course. In addition, their self-efficacy and mindset in teaching mathematics grew through the course, as evidenced in their responses to open-ended questions. The results showed that learning about variety of inductive teaching styles of mathematics, learning and practicing variety of differentiation for inclusion techniques, and learning to support productive struggle in mathematics classroom most helped the preservice teachers grow their mindset in teaching mathematics. Planning, writing, and implementing an inductive style lesson, and going through struggle in class, as well as learning to support productive struggle through asking questions helped them to improve their self-efficacy in teaching mathematics.

References


Appendix

Self-efficacy for Teaching Mathematics Instrument (SETMI)
Elementary Teacher Version

Directions: Please circle the number that matches your response.

<table>
<thead>
<tr>
<th>None at All</th>
<th>Very Little</th>
<th>Strong Degree</th>
<th>Quite a Bit</th>
<th>A Great Deal</th>
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1. To what extent can you motivate students who show low interest in mathematics?  
   1 2 3 4 5

2. To what extent can you help your students' value learning mathematics?  
   1 2 3 4 5

3. To what extent can you craft relevant questions for your students related to mathematics?  
   1 2 3 4 5

4. To what extent can you get your students to believe they can do well in mathematics?  
   1 2 3 4 5

5. To what extent can you use a variety of assessment strategies in mathematics?  
   1 2 3 4 5

6. To what extent can you provide an alternative explanation or example in mathematics when students are confused?  
   1 2 3 4 5

7. How well can you implement alternative teaching strategies for mathematics in your classroom?  
   1 2 3 4 5

How well can you teach students to...

8. Describe characteristics of Numbers (i.e. whole numbers, rational/irrational numbers).  
   1 2 3 4 5

9. Perform strategies for composing and decomposing numbers by manipulating place value in addition and subtraction.  
   1 2 3 4 5

10. Perform strategies for composing and decomposing numbers by manipulating place value in multiplication and division.  
    1 2 3 4 5

11. Convert a fraction to a decimal and vice versa.  
    1 2 3 4 5

12. Compare equivalence of fractions and decimals  
    1 2 3 4 5

13. Interpret inverse relationships between operations (i.e. +, - and *, ÷)  
    1 2 3 4 5

    1 2 3 4 5

15. Collect, plot and interpret data (on any type of graph)  
    1 2 3 4 5

16. Measure area and perimeter  
    1 2 3 4 5

17. Convert between units in the same system (i.e. grams → kilograms, inches → yards).  
    1 2 3 4 5

18. Convert between units in a different system (i.e. kilograms → pounds, inches → centimeters).  
    1 2 3 4 5
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<td>19.</td>
<td>Measure the length of objects.</td>
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<td>20.</td>
<td>Discover and create mathematical patterns</td>
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<td>21.</td>
<td>Interpret variables in an algebraic equation.</td>
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<td>22.</td>
<td>Interpret probability of outcomes</td>
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