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The effects of a mediated field experience methods course on pre-service elementary mathematics teachers' beliefs

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ABSTRACT

A mediated field experience (MFE) mathematics methods course increased both pre-service elementary teachers' (PSTs) self-efficacy for teaching mathematics and mathematical dispositions. The semester-long MFE with significant, structured teaching experiences was conducted onsite at an elementary school. Quantitative, pre- and post-surveys of mathematics teaching efficacy revealed statistically significant increases over the semester. A qualitative analysis of PSTs as sophomores and seniors further explored and supported this increase in PSTs' self-efficacy for teaching mathematics. Qualitative data also revealed interesting changes in mathematical dispositions and a shift in PSTs from a self-as-student perspective to a self-as-teacher focus.

Keywords: teacher beliefs, pre-service teacher education, methods courses, mathematics education, elementary teacher education

INTRODUCTION

Pre-service elementary teachers (PSTs) have perennially struggled with efficacy in mathematics and mathematics teaching (Bates et al., 2011; Feldhaus, 2014; Ganley et al., 2019). This lack of efficacy contributes to negative dispositions towards mathematics and low efficacy for teaching mathematics with one study noting that 39% of PST elementary teachers selected mathematics as their most unliked subject (Brady & Bowd, 2005). One factor contributing to this lack of efficacy could be the high proportion of PSTs who struggle with mathematics anxiety (Brown et al., 2012; Gresham, 2009) with elementary education majors reporting the highest levels of mathematics anxiety among college majors (Beilock et al., 2010). These negative mathematical dispositions have effects on both the teachers and their students.

Problem

Elementary teachers play a vital role in their students' mathematical experience. Teachers' dispositions towards mathematics impact the mathematical dispositions of their students (Feldhaus, 2014). Multiple studies have established a link between a teachers' disposition towards mathematics and their students' mathematics achievement (Cruz et al., 2019; Lin & Tai, 2016; Op't Eynde et al., 2002; Tobias & Weissbrod, 1980). A teacher's disposition affects their actions. Teachers with negative emotions used shallower learning opportunities (Frenzel et al., 2021) and tended to be more rigid and less likely to adapt pedagogy to meet the needs of their students. A strong association also exists between a teacher's disposition towards mathematics and their mathematics teaching efficacy (Thomson et al., 2020). Negative dispositions in PSTs were associated with lower levels of mathematics efficacy and mathematics teaching efficacy (Bates et al., 2011; Gresham, 2009).

PSTs who lack efficacy to teach mathematics are a great concern since their lack of confidence affects their teaching. These PSTs are less likely to implement research-based best practices for teaching mathematics. Efficacy beliefs motivate and promote learning through a teacher's pedagogical outlook, the learning environments they create, the pedagogical choices they make, and ultimately their students' achievement (Bandura, 1993; Philippou & Christou, 2003). Efficacious teachers are more likely to implement reform initiatives including practices that emphasize critical thinking and to "set higher goals for themselves and for their students" (Kahle, 2008; Thomson et al., 2020, p. 5). These high goals demand an effective use of instructional time. Teachers with higher self-efficacy had fewer interruptions and off-topic conversations with students; efficacious teachers also gave attention to all students including those who struggle in comparison to teachers with lower self-efficacy who avoided lower ability students (Hickman & Sherman, 2019).

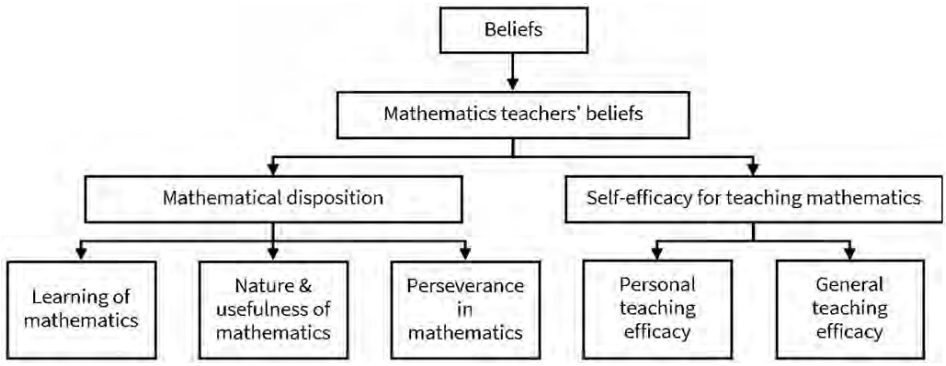

Figure 1. Theoretical framework of mathematics teachers' beliefs (Cruz et al., 2019)

Theoretical Framework of Mathematics Teachers' Beliefs

Cruz et al.'s (2019) theoretical framework of mathematics teachers' beliefs (see **Figure 1**) provides a helpful structure to examine PST beliefs in the current study. The framework identifies two aspects of mathematics teachers' beliefs:

(1) mathematical dispositions and

(2) self-efficacy for teaching mathematics.

Following this structure, mathematical dispositions include the learning of mathematics, the nature and usefulness of mathematics, and perseverance in mathematics. It should be noted that the learning of mathematics often falls in two broad categories of behaviorist and constructivist perspectives (Cruz et al., 2019). PSTs' beliefs about themselves as teachers of mathematics will be termed self-efficacy for teaching mathematics and includes both general teaching efficacy and personal teaching efficacy. General teaching efficacy describes an individual's belief that effective teaching will improve student learning (Enochs et al., 2000). Personal teaching efficacy is a PSTs' belief in their ability to bring about positive learning outcomes in their classroom as a result of their pedagogy (Chester & Beaudin, 1996).

Given the importance of teacher efficacy in teaching mathematics and student achievement, calls to improve elementary teachers' self-efficacy for teaching mathematics (Thomson et al., 2020) have included specific requests for teacher preparation programs to examine the beliefs that PSTs bring to education and "provide experiences that help students overcome common myths and misconceptions about mathematics, its teaching and learning" (Philippou & Christou, 2003, p. 216). This is a valuable avenue of research as there is evidence that PST's efficacy for teaching mathematics can grow (Giles et al., 2016) and that teacher education programs can make a difference.

Mediated Field Experience

Fieldwork is an important aspect of all teacher preparation programs and a key lever in increasing elementary PST's self-efficacy for teaching mathematics. Experience teaching mathematics, particularly positive field work experiences, contributes to increases in teaching efficacy since "PSTs' efficacy beliefs in mathematics are amenable to change" during their field work (Charalambous et al., 2007, p. 139). Similarly, Brown et al. (2012) noted that authentic, repeated K-12 classroom mathematics teaching experiences gave PSTs more confidence in the act of teaching mathematics. Given the importance of fieldwork, a solution for negative dispositions and lack of efficacy towards mathematics in PSTs is a mediated field experience (MFE) mathematics methods course. An MFE methods course holds "a portion or all of a methods course in an elementary or secondary school" (Zeichner, 2010, p. 93). In MFE courses, PSTs experience a wide range of aspects of teaching, which could include lead teaching, co-teaching, one-on-one remediation or enrichment, assessing student work, and lesson planning. The methods course in this research included structured experiences in second grade classrooms, where PSTs were actively engaged with students.

An MFE requires intentional changes in the methods course (Zeichner, 2010). This includes deeper preparation for practicing key co-teaching strategies (Friend & Cook, 2000) and dedicated time and protocols for PSTs to receive feedback and reflect on their teaching in the K-12 classroom (Horn & Campbell, 2015). Feedback is an important aspect in developing mathematics teachers' perception of self-efficacy (Calhoun, 2019) as it helps PSTs identify how to approach the challenges associated with teaching and receive affirmation for their strong pedagogical moves.

Research Question

RQ. What are the effects of an MFE mathematics methods course on PST's positive dispositions and self-efficacy for teaching mathematics?

METHODS

Participants

Participants were undergraduate students at a small liberal arts university in the Midwest. All students were elementary education majors enrolled in a methods of teaching elementary mathematics course in the Fall 2018 or Fall 2019 semesters. Students in this course were predominantly seniors and will be referred to as senior PSTs throughout the remainder of this paper.

Thirty students were enrolled in the methods course in 2018 and 29 students in 2019, for a total of 59 students. To be included in the research, students completed an on-campus mathematics content course, *mathematics for elementary teachers*, and the qualitative pre-test response regarding topics that excite and scare them about teaching mathematics. Students typically enroll in the mathematics content course during their freshman or sophomore year. These students will be referred to as sophomore PSTs throughout the remainder of the paper. Students in the study took *mathematics for elementary teachers* course between the Spring 2016 and Spring 2019 semesters. One student did not complete the pre-test in the *mathematics for elementary teachers* course and was not included in the research producing a sample of 58 elementary education students. All teachers in this study were between 18 and 22 years of age. Six students were male; the remaining students were female. Three students were ethnic or racial minorities; the remaining students were Caucasian.

Intervention

A partnership was formed between the university and a local elementary school with a goal of providing authentic mathematics teaching experiences for their PSTs to develop competence and confidence. To accomplish this goal, an MFE elementary mathematics methods course was conducted onsite at the local elementary school with time spent in the three class sections of second grade mathematics during the Fall semesters of 2018 and 2019.

The school provided a classroom, where the methods course could meet when not in the second grade classrooms. The methods course met for 75 minutes on Tuesdays and Thursdays and was designed to incorporate mediated field instruction. Professors met regularly with the cooperating elementary school teachers prior to and throughout the semesters. Clear protocols were established to ensure that all PSTs would be actively involved in mathematics teaching experiences and that the elementary students would receive high quality instruction. The elementary teachers' primary focus was to improve the learning of their students, but they were also committed to the growth of PSTs and provided valuable feedback and encouragement. A lesson plan template was designed in cooperation with the teachers, which combined elements of the lesson plan template of the university education department, mathematics specific additions such as error analysis, and elements that incorporated routines used in the 2nd grade classes including "I can" statements (**Appendix A**).

To ensure PSTs were confident and comfortable in the context they were stepping into, the plan for the semester began with a focus on information specific to planning mathematics classes, while gradually increasing time and responsibility in the second-grade classroom. PSTs remained with the same second grade class throughout the semester to increase their comfort level and build relationships with students. This allowed PSTs to focus on their pedagogy in a familiar setting. Each second grade class was assigned nine or ten PSTs.

The gradual introduction to the second grade started in the second week of the semester. The second grade teachers joined PSTs for 20 minutes to share about their classroom design, the mathematics curriculum, and their second grade students developmental characteristics and needs. The teachers used a response to intervention (RTI) approach in mathematics in which assessments were followed by a day, where second grade students across all three sections were divided into groups according to their achievement on the assessment and given instruction specific to their level of mastery. PSTs observed an RTI class in the third week of the semester. To prepare for this class PSTs analyzed the four lessons covered in the assessment and submitted a paper that outlined the key point of each lesson and possible errors to anticipate. PSTs observed RTI in the second grade class for the first 40 minutes and then transitioned to their own classroom at the elementary school, where they met for an additional 35 minutes to discuss what they observed.

The fourth week of the semester was the first time that PSTs directly interacted with the second grade students by administering a fact fluency assessment to small groups of second grade students. Weeks five and six did not have PST's in the second grade classroom as they completed foundational learning prior to leading instruction. They also took an exam covering best practices for mathematics pedagogy and had a fall break.

In week seven of the semester, PST's observed a lesson on both class days and assisted individual students as needed during individual work time. To prepare for these observations PST's completed portions of the lesson plan template (unit of study, key idea, content standard, error analysis, vocabulary). After class, PSTs completed their initial lesson plan based on what they observed in the classroom.

In weeks eight through 13 PST's led instruction for the first 40 minutes of class every Tuesday and Thursday. This included two fact fluency days, three RTI days, and six days of whole group instruction of a lesson. All lessons were planned and cotaught in groups of two to three PSTs and methods instructors gave feedback on each lesson plan prior to class to develop PSTs' planning ability, increase PSTs' confidence in their plan, and to ensure high-quality instruction. Prior to fact fluency days, PSTs used student data provided by the second grade teachers regarding individual student mastery of addition or subtraction facts to create groups of two to five students with similar ability in fact fluency. PSTs designed and cotaught lessons that emphasized conceptual understanding of mathematics facts targeted to the needs of the students in their small group.

On RTI days following assessments, PSTs planned and cotaught groups of two-six students. Using student achievement on the assessment, the second grade teachers made student groups labeled remediation, on-level, and enrichment. The teachers appreciated the focused attention that their students received on these days. It should be noted that while PSTs stayed with the same second grade class throughout the semester, this was not possible on RTI days as the second grade teachers made groups across class sections.

On whole group instruction days, PSTs were assigned in groups of three to one of three roles: lead teacher, para-professional, or peer feedback. Six whole group instruction days resulted in each PST serving in each role two times during the semester. PST lead teachers cotaught and were responsible for creating the lesson plan, communicating the lesson goals with the other PSTs in the classroom, and giving clear instructions to classmates assigned to the para-professional role on their responsibilities for the

day. PST para-professionals supported the lead teachers and were often asked to work closely with an individual student or conduct a station. PSTs in the peer feedback role took notes throughout the lesson on what worked well, student responses, and led the reflection time.

Group debriefing occurred after each second grade lesson for 35 minutes and was a time of rich learning. The atmosphere was electric as PSTs shared their experiences about what went well and how they would change the lesson if they taught it again. Clear feedback protocols were essential to support the reflection process and all PSTs were instructed in best practices for giving feedback. On RTI and fact fluency days debriefing included time to share observations across the groups of students. Debriefing after whole group instruction was done in groups according to the classroom they were assigned to and was led by PSTs in the peer feedback role. Suggestions were given in the form of "I wonder" questions to help PSTs not feel threatened by feedback. Five minutes were also given each day for PSTs to communicate plans and preparations for the next day of teaching.

The final three weeks of the semester were spent at the university consolidating their learning experiences through discussion and completion of final assignments including a unit plan and a philosophy of teaching mathematics paper.

Data Collection

Data collection for this research took multiple forms and was embedded in two courses required of all PSTs, the mathematics content course typically taken as sophomores and the *methods of teaching mathematics* course taken by seniors in the fall semester.

To assess changes in senior PSTs' efficacy as a result of MFE, PSTs completed the personal mathematics teaching efficacy (PMTE) subscale of the mathematics teaching efficacy belief instrument (MTEBI) on the first and last day of class (Enochs et al., 2000). The subscale includes 13 items with a six-point Likert scale response ranging from strongly disagree to strongly agree. Eight of the items are stated in the negative form and responses were reversed for data analysis purposes. Negatively worded questions included questions such as, "I wonder if I have the necessary skills to teach mathematics." Positively worded questions included, "I understand mathematics concepts well enough to be effective in teaching elementary mathematics." The results were entered into a spreadsheet by an administrative assistant who replaced each PST's name with their identification number to allow for pre-test post-test matching and to ensure that PSTs' responses were linked but anonymous to researchers.

Qualitative data regarding what excites and scares PSTs about teaching mathematics was embedded in the sophomore mathematics course and the senior mathematics methods course. The pre-test occurred as a journal assignment in the first week of the sophomore mathematics course. In the prompt, PSTs are asked to write a mathematics autobiography reflection on the three reflection questions below.

1. What is your mathematics autobiography? (Your history with mathematics?)
2. What excites you about mathematics?
3. What scares you about mathematics?

The post-test occurred during the final exam of the mathematics methods course taken in the fall of the senior year. Questions 2 and question 3 from above are posed as reflection questions and are graded on completion.

Data Analysis

Quantitative analysis methods

Researchers began by reversing the eight items on MTEBI stated in the negative form. Next, the results of the pre- and post-test MTEBI were matched by PST and researchers calculated an average score on the pre- and post-test including a difference score by PST. Difference scores for all analyses were calculated subtracting the pre-test average from the post-test average to show change as a result of the intervention.

The average and standard deviation of the pre-test, post-test, and difference scores for MTEBI were calculated. Researchers conducted an item analysis finding the average pre-test, post-test, and difference score of MTEBI by question. Internal consistency for the 13 pre-test (α=.86) and post-test (α=.80) questions was good. Two-sided, matched pairs *t*-tests were used to calculate statistical significance using an *alpha* level of .05. Power to detect effects for a matched pairs t-test was calculated using G*Power (Faul et al., 2009).

Qualitative analysis methods

The researchers first reviewed de-identified responses for the question "what excites you about mathematics?" for common themes. The first author identified overall themes when the responses were originally used as a course assessment. These original themes as well as those identified in process were utilized by the second author to code responses. The first author then used all themes used by the second author to independently code each response. Authors then met and discussed any differences between themes identified until they reached consensus. Authors then reviewed the model provided in Cruz et al. (2019) and jointly evaluated the fit between the model and the identified themes. Authors perceived alignment between the model and the themes and aligned their theme identifiers with the model.

Researchers next reviewed de-identified responses to the question "what scares you about mathematics." The first author did not identify any themes from the original use of the responses as a course assessment. The second author identified and coded themes for the responses. The first author used themes identified by the second author as well as identifying a few more themes while independently coding the responses. Authors again met and reviewed themes and coding until consensus was reached. Authors then reviewed the model provided in Cruz et al. (2019) and jointly evaluated the fit between the model and the identified themes. Authors perceived alignment between the model and the themes and aligned their theme identifiers with the model.

Table 1. Descriptive statistics & paired *t*-test analysis of MTEBI

Instrument	Pre-test		Post-test		t(57)
	Mean	Standard deviation	Mean	Standard deviation	
MTEBI	3.84	0.69	4.34	0.53	6.77*

Note. *Denotes significant difference at .05

Table 2. MTEBI item analysis–Positive wording

Item	Pre-test		Post-test		t(57)
	M	SD	M	SD	
1. I will continually find better ways to teach mathematics.	5.41	0.56	5.55	0.57	1.34
3. I know how to teach mathematics concepts effectively.	3.35	1.05	4.58	0.88	7.43*
6. I understand mathematics concepts well enough to be effective in teaching elementary mathematics.	4.63	1.10	5.21	0.72	3.94*
8. I will typically be able to answer students' questions.	4.35	1.05	4.84	0.87	3.64*
12. When teaching mathematics, I will usually welcome student questions.	5.16	0.89	5.47	0.65	3.04*

Note. *Denotes significant difference at .05; M: Mean; & SD: Standard deviation

Table 3. MTEBI item analysis–Negative wording

Item	Pre-test		Post-test		t(57)
	M	SD	M	SD	
2. Even if I try very hard, I will not teach mathematics as well as I will most subjects.	3.60	1.28	3.70	1.32	0.47
4. I will not be very effective in monitoring mathematics activities.	3.79	0.95	4.03	1.01	1.59
5. I will generally teach mathematics ineffectively.	4.07	0.84	4.33	0.89	1.90
7. I will find it difficult to use manipulatives to explain to students why mathematics works.	3.69	1.00	4.40	0.75	5.43*
9. I wonder if I have the necessary skills to teach mathematics.	2.47	1.58	3.36	1.33	4.68*
10. Given the choice, I will not invite the principal to evaluate my mathematics teaching.	2.94	1.46	3.35	1.38	1.53
11. When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better.	3.62	1.02	4.12	0.84	4.13*

Note. *Denotes significant difference at .05; Negatively worded questions were reversed; M: Mean; & SD: Standard deviation

Throughout the review of the responses, the researchers were attentive to patterns of responses that differed between sophomore and senior year both across all participants and within a single participant. Researchers assigned gender matched, randomly selected pseudonyms to participants to aid comprehension.

RESULTS

The results of MFE were largely positive and PSTs valued the experience. As Kristine stated as a senior,

> being in the second grade classroom made me realize how much more exciting mathematics is to me when you add the people … it is so much more beneficial, and it comes to life when I see students working on it and working together.

Agnes, a senior, commented on her growth and confidence as a mathematics teacher,

> I have a small feeling of confidence after being at [the school]. Throughout the semester, my feelings of "being scared" have begun to diminish through the experiences provided in the 2nd grade classroom. I have been able to gain a significant amount of "I can do this" throughout the course of this semester. I am a much different "mathematics teacher" now than what I was at the beginning of the semester.

This data was part of a larger study that examined PST course feedback (Zonnefeld & Zonnefeld, 2020). IDEA student ratings of instruction instrument indicated PSTs felt the intervention was positive, "13 items with statistically significant improvement at a *p*-value threshold of 0.05 and seven items with significance at a p-value threshold of 0.01" (p. 3). The remainder of this section will share specific themes in the quantitative data results followed by the results of the qualitative data.

Quantitative Analysis Results

MTEBI subscale of PMTE (Enochs et al., 2000) was used to assess changes in PSTs' efficacy over the semester. The subscale includes 13 items, which incorporate a six-point Likert scale ranging from strongly disagree to strongly agree. Eight of the items are stated in the negative form and were reversed for data analysis purposes, as noted below. The descriptive statistics and paired *t*-test analysis for MTEBI are given in **Table 1**. PSTs' mathematics efficacy and mathematics teaching efficacy increased over the semester as measured by MTEBI (μ_{pre}=3.84, μ_{post}=4.34, $\mu_{difference}$=.51). A paired *t*-test noted a statistically significant increase in PSTs mathematics and mathematics teaching efficacy $t(57)=6.77$, $p<.000$. A post hoc examination of power indicated adequate power to detect effects with a paired *t*-test (d=.883, 1-β=.989, n=58).

An item analysis of the 13 questions in MTEBI was also conducted. **Table 2** depicts the analysis of the positively worded items while, **Table 3** depicts the negatively worded items. Nine of the 13 items analyzed depicted statistically significant differences.

Qualitative Analysis Results

A qualitative analysis of PSTs responses to the open-ended questions further explores factors underlying the increase in PSTs' MTEBI scores over their senior semester. The qualitative data, however, was organized with the same PSTs' responses to the same questions as sophomores. This allowed some measure of how an individuals' responses to these questions changed over time. Comments from sophomore responses are used to support claims that PSTs have changed. The changes in the qualitative data support the within semester changes in the quantitative data.

PSTs as sophomores were similar to education majors described in the literature. They demonstrated low self-efficacy for teaching mathematics (Bates et al., 2011; Brown et al., 2012; Feldhaus, 2014; Gresham, 2009) and negative mathematics dispositions (Beilock et al., 2010). Many described mathematics as their least favorite class (Brady & Bowd, 2005). Lynn's negative mathematics disposition is representative of the statements made by many PSTs as sophomores.

> I get frustrated and easily confused when I do not understand a concept … I also find that I get irritated that mathematics comes so easily to some people and not to me. I am horrible at mental math, so I get embarrassed because I often get problems wrong (Lynn, sophomore).

The nature of PSTs' mathematics dispositions and self-efficacy for teaching mathematics changed from sophomore to senior year.

As seniors, PSTs expressed mathematical dispositions that were more positive in orientation regarding the aspects of the nature and usefulness of mathematics, the importance of perseverance in mathematics, and the active ways mathematics is best learned. These mathematical dispositions reflected both factors that excited them about teaching mathematics and factors that made them anxious about teaching mathematics. The self-efficacy for teaching mathematics more strongly represented personal teaching efficacy than general teaching efficacy. Within their personal teaching efficacy, PSTs considered what it will be like to teach students who struggle, their students' mathematics anxiety, and students grasping difficult concepts. Finally, some interesting transitions in PSTs from sophomore to senior year are highlighted in both the mathematical dispositions and the self-efficacy for teaching, and some other overarching transitions that seem to have occurred in this time.

Mathematical dispositions

PSTs both early in their education and in their senior year expressed particular aspects of the nature of mathematics that both scared them and excited them. The *nature and usefulness of mathematics with real life applications* was particularly mentioned by many PSTs. These are positive dispositions concerning the applicable nature of mathematics. Rose reflected on the positives and excitement about the ability to connect mathematics to life.

> Mathematics makes me excited because it is a relevant, applicable subject area that is a part of everyday life. I love identifying ways that mathematics can be used to help me in my day-to-day activities, from baking bread to calculating savings in a store (Rose, senior).

However, a number of PSTs demonstrated negative dispositions connected to the real-life applicability of mathematics. For instance, Gwendolyn wrote about her anxieties in making real-world connections, which were based upon her low efficacy in mathematics. This negative disposition then directly affects her PMTE because of her beliefs about the experience of learning mathematics,

> Mathematics still scares me because I struggle to develop real-world examples by myself … I am still developing my conceptual understanding, and I would much rather give students a formula to plug numbers into than help them discover the formula on their own through exploration and hands-on activities (Gwendolyn, senior).

Other PSTs also explicitly connected low personal teaching efficacy to their ability to communicate the applicability of mathematics. Daisy, a senior, wrote,

> I fear I will teach mathematics in a way that does not connect to their personal lives, because I did not see much of it when I was younger … I fear with so little time [in the classroom] I will rush past what is truly important in mathematics and everything in life: the "why" (Daisy, senior).

Some PSTs connected the relevance of mathematics to student attitudes towards mathematics and their learning of it, giving the communication of the real-life applications even more significance. Cherie, a senior, tied her personal teaching efficacy and her mathematics efficacy to the nature and usefulness of mathematics and to perseverance in mathematics when she wrote

> I need to show my students that mathematics is so important, relevant, and rewarding, so they need to persevere through the challenge even though I did not always do this myself … I do not want it to be my fault that students are not excited about mathematics because I know the teacher play a large role in student emotions and attitudes towards mathematics (Cherie, senior).

Other PSTs connected the real-life applications of mathematics to their and their students dispositions about learning mathematics and the quality of mathematics related school experiences. Seniors reflected on their ability to improve upon their own school experiences because mathematics can be connected to relevant examples in spite of their own learning experiences not reflecting this. Kate, a senior, wrote,

> One thing that excites me is the chance I have to instill a love and appreciation for mathematics in my students. I have a chance to teach them mathematics in a way it was not taught to me (Kate, senior).

When comparing PSTs reflections as sophomores to their reflections as seniors, the changing focus from themselves as the student to themselves as the teacher is particularly apparent as they consider this overlap between the nature of mathematics and their beliefs in the active nature of learning mathematics. Marianna's reflection on this as a sophomore shows the self as student perspective,

> What I am most excited about for taking a mathematics class is the fact that it's almost impossible to lecture for an hour in a mathematics class; to learn math, you have to do it (Marianna, sophomore).

When PSTs were seniors their thoughts on the nature of mathematics had transitioned to an orientation that prioritized their students' learning over their own educational experiences. This is apparent in Marianna's response as a senior.

> The thing that excites me most about mathematics is the opportunity it provides to get students engaged in hands-on, minds-on problem solving … I am excited to engage my students in problems that require creative thinking, debating and defending answers, collaborative work, and more. There are also a wide range of mathematics games that can be used to enhance students' understanding, more so than you typically see in subjects like reading or language arts (Marianna, senior).

Not only was the nature and usefulness of mathematics to real-world experiences an important aspect of the nature of mathematics, the ease of demonstrating mathematical concepts through hands on activities and active learning mattered to many of PSTs because of their beliefs about learning mathematics.

Another aspect of *the nature and usefulness of mathematics* is that mathematics ability is less dependent on English proficiency than other subjects. This allows students who are English language learners a different opportunity to demonstrate their ability in mathematics, where language skills have a lesser impact. This was noticed by PSTs who worked with students who were English language learners,

> In my student teacher we have 4 ELL students who really struggle to read, and it is so exciting and fun to see them succeed in mathematics. Although word problems can still be challenging, mathematics is almost a breath of fresh air for these students (Maggie, senior).

The nature and usefulness of mathematics as relevant in the real world, as learned through hands on activities, and as less dependent on language proficiency were themes across PST comments about both what excited them and made them anxious to teach mathematics.

Another aspect of mathematics that demonstrated differing perspectives between sophomores and seniors was the considerations about the importance of *perseverance in mathematics*. Mathematics often challenges students to invest significant time and effort to learn. Sophomore PSTs focused on the challenge of mathematics for themselves. They were excited as learners to demonstrate their understanding. As seniors PSTs were still excited about the challenge of mathematics but they tended to focus on how that challenge would bring excitement to their classrooms. Nikki is an example of that transition. As a sophomore, her focus was entirely on her own experience of mathematics,

> What excites me about mathematics is the challenge of being able to think through things logically and figure them out. In the past, I have really enjoyed having challenging mathematics homework that makes me think deeply and consider other ways of figuring things out (Nikki, sophomore).

However, as a senior, the focus transitions towards her students enjoying the challenge of mathematics,

> One of the things the excites me most about mathematics is the challenge. I enjoy being challenged and working toward a goal of solving a problem or figuring something out. I hope to share this same excitement with my students and to help them see the fun in learning and in being challenged. I hope they can enjoy being challenged, enjoy the learning and growing process, and enjoy the satisfaction of working hard to accomplish a goal (Nikki, senior).

The transition from self as learner centric to student centric was apparent in the way many PSTs expressed their appreciation of the challenge of mathematics.

As part of appreciating the challenge of mathematics, some PSTs developed value for the role of productive struggle in mathematics. The appreciation of productive struggle demonstrates a deepening of the understanding of mathematics and the learning of mathematics. Kyla, as a sophomore and a senior displays this growing appreciation for productive struggle over a preference for algorithmic computational,

> Mathematics excites me when I know exactly what I'm doing. As long as I understand the question or the formula, I will enjoy solving it. I love doing mental mathematics when possible. I also like writing out long formulas when I know the steps (Kyla, sophomore).

> There is a lot that excites me about mathematics. Being able to struggle hard on a mathematics problem and then eventually solve it really excites me to try another. Finally understanding the major concepts of mathematics compared to

> memorized procedures excites me to teach my students mathematics in a way that connects to them more than when I was their age (Kyla, senior).

Mathematics as a challenging field, where the development of perseverance provides positive reinforcement was identified by PSTs as a reason for excitement about learning and teaching mathematics. A particular aspect tied to positive dispositions towards mathematics across all of its aspects identified by PSTs was the problem-solving aspect of mathematics. PSTs frequently mentioned excitement about the problem-solving experience mathematics can be. They anticipated sharing this excitement with their future students.

> I think that mathematics is exciting because it's solving a problem. This is a skill that can be built up very strongly in regards to numbers but also in bigger picture problems … I am excited by the fact that we can use logic and creativity to solve problems. We can go beyond numbers and really develop our problem solving skills when we approach mathematics in the right way (Sheryl, senior).

Overall, PSTs displayed more positive mathematical dispositions in the way they discussed the learning of mathematics, the nature and usefulness of mathematics, and the role of perseverance in mathematics. They discussed teaching mathematics with a deep appreciation for the active roles of critical thinking and active problem solving, the dynamic and applicable nature of mathematics, and the importance of productive struggle and perseverance in mathematics.

Self-efficacy for teaching mathematics

As seen above, PSTs self-efficacy for teaching mathematics was also illustrated in their comments. For the most part comments focused on aspects of personal teaching efficacy over general teaching efficacy. Given the questions and their stage in the teacher preparation program, it is appropriate that most PSTs had a positive general teaching efficacy. They believe that teachers matter. Their concerns about their own ability to have a positive effect on their students as a teacher, their personal teaching efficacy, was a common theme of their worries about teaching mathematics. However, even as they noted concerns, interestingly, many PSTs offset their concerns with specific ways to address particular problems. Positive beliefs and excitement to teach were also reflected in their response to the excitement for teaching question, often focused on their excitement to engage in the teaching process itself.

Helping students who struggle and coping with student mathematics anxiety were common themes related to their teaching efficacy in the reflections on what made them anxious to teach. PSTs wanted to share their love of mathematics, to see students "get it." Many were excited and anxious about developing their own pedagogy.

Self-efficacy for mathematics, their beliefs about their own abilities to do mathematics, was a factor for some PSTs. Sophomore PSTs often had concerns about their personal teaching ability for mathematics. After the practical experience of MFE, seniors were more specific about their teaching strengths and areas for development.

> I'm scared with my personal ability in mathematics. I already struggle a little with mathematics on my own so I'm scared that I will not be a good teacher for mathematics. I'm nervous that I will not be able to express or teach mathematics ideas in ways that are understandable for my students. I'm scared that if I do not understand the mathematics I will not be able to answer questions for students. When explaining step by step procedures and students ask why it is done that way, I want to have an answer for them and I'm nervous that I will not be able to (Kathie, sophomore).

This particular PST still had low personal teaching efficacy for mathematics after MFE, but her anxieties were more concrete and were balanced by acknowledging potential solutions to problems,

> One thing that scares me the most is knowing how to effectively teach and communicate mathematics to all the different learning needs of my students. With mathematics, I find that I have a hard time conveying it to other people. I may be able to understand it and make sense of it one way, but if a student does not understand it and requires more explanation or a different method, I'm scared that I will not know what to do to help them understand. I have learned through this course, how to be flexible in my thinking and the different resources that are available to help me, so I have a little more confidence in myself and abilities now than when I first started this course (Kathie, senior).

A major factor within personal teaching efficacy is beliefs about the ability or inability for their teaching to have positive results. We identified several subthemes within their beliefs about themselves in this regard. PSTs commented in particular on teaching students who struggle, dealing with mathematics anxiety in students, and having students grasp difficult concepts.

PSTs expressed low personal teaching efficacy in particular regarding teaching students who struggle and not knowing how to help them. This was true for both PSTs with high self-efficacy for doing mathematics and low self-efficacy for doing mathematics. However, the reason this was concerning seemed to differ by self-efficacy for doing mathematics. Some PSTs were anxious because they have always understood mathematics and are afraid they will not be able to relate to students who struggle.

> The part about teaching mathematics that also scares me is having a student that really struggles in mathematics and not being able to figure out how to help him because mathematics has always been something I liked and understood (Rosa, senior).

Other PSTs, though, were anxious because they are not strong in mathematics themselves and so were afraid they would not be able to explain aspects of mathematics, where they struggle.

> The one thing that scares me about math, is not understanding the content I will be teaching or not being able to answer questions students have … It scares me to think that one of my students might not understand and get behind in the mathematics lessons because I did not or could not answer their questions (Dora, senior).

PSTs who enjoy mathematics themselves were excited to teach others about it because they want to share their enjoyment of it:

> I am excited to teach mathematics in general to my students. I have always been excited about doing math, and now I will get to use that excitement in order to teach my students … I hope that my excitement for mathematics can transfer to my students in order to help them be excited about mathematics as well (Elvira, senior).

Mathematics anxiety was a common theme across PST responses. Regardless of their own self-efficacy for doing mathematics, many PSTs were concerned about mathematics anxiety in their students. They were concerned both about confronting existing mathematics anxiety,

> I am worried about interacting with students who have strong mathematics anxiety. What if a student just cannot get past that? … I just do not want to let a student leave my class without being able to do the mathematics concepts that are required of them (Gloria, senior).

and about creating the mathematics anxiety with their teaching,

> I am also scared about creating mathematics anxiety in students in my classroom. I want my students to feel safe to make mistakes and try new things and I want them to overcome learned helplessness, where mathematics is concerned (Blanche, senior).

A common theme within the personal teaching efficacy was PSTs excitement to experience students grasping difficult concepts. They wanted to experience that "a-ha" moment when students "get it".

> … when you can see the understanding click in students minds it is also a great time of learning and feeling of success for them. Students may not always feel that but the drive and the determination to do so is something that really excites me and the way I will challenge my students some day (Kristine, senior).

> Mathematics also excites me because I have witnessed previous tutor students and practicum students … experience the amazing "a-ha" moments to which absolutely nothing compares. I have seen this so much more evidently in mathematics this fall than I have in literature or language, so that makes me excited about mathematics (Peggy, senior).

General teaching efficacy was not prevalent in PSTs comments, however personal teaching efficacy was a frequent source of both worries and excitement for teaching. PSTs were worried that their own mathematics ability would negatively impact the classroom, about the role of student mathematics anxiety in their classroom, and that they would not be able to help students who struggle. PSTs were also excited to develop in their ability to handle these concerns. The seniors were more concrete about how these scenarios made them anxious, and so were able to supplement the worries with potential solutions. Many PSTs commented on their excitement to experience the effectiveness of their own teaching.

Differences between sophomore & senior responses

Although the focus of this research is on the senior PSTs' responses after completing their MFE as support for the within semester changes in quantitative scores for teaching self-efficacy, the data was aligned to show us sophomore responses paired with the same PSTs' senior responses. In the prior sections some of those transitions of particular relevance to mathematical dispositions and self-efficacy for teaching mathematics were highlighted. There were a few other transitions that were highly apparent in comments and likely related to both their continued progress through their teacher preparation courses, but also probably connected to their lived experiences during the MFE.

The transition from a sophomore focus on their own mathematics performance to a senior focus on their future students' achievement was clear in the content of their reported anxieties. Although this cannot be attributed to MFE experience exclusively, time teaching in a classroom likely strengthened this thought transition. Sophomores were more often anxious about their own ability to do specific types of mathematics, demonstrating low mathematics efficacy.

> It gives me anxiety to look at a problem and feel so helpless about ever solving it … I am so self conscious about my mathematics skills and become so embarrassed when I am not able to understand something that seems so easy for others to understand (Cherie, sophomore).

Most seniors were anxious about their ability to help others do mathematics demonstrating low personal teaching efficacy. Their focus had largely transitioned from a self as learner perspective to concern for future students.

> One thing that scares me about mathematics is not having the right answer, for both me and my students. It is a subject I struggle in personally, so it is the subject that I am most scared to teach. I want to make sure that my students are learning in a way that is effective, and that means I need to know the content well. I know that this subject will take more planning

> than the others, and I fear that I will still not know the content well enough or teach the strategies well enough (Kate, senior).

Progress across time can be seen particularly in comparing Beverly's responses as a sophomore and a senior,

> I am scared of mathematics because I do not like getting frustrated and not understanding the problems set before me. I am also scared of not being aware that my answer is wrong, and doing an entire assignment incorrectly but turning it in because I do not know it is (Beverly, sophomore).

> What scares me about mathematics is messing up and teaching something wrong, or not being able to explain in a way that my students understand … Not knowing how to explain concepts to students is a fear, but I also can grow through this fear as I can learn from my students as well, as some may come up with unique ways to solve problems (Beverly, senior).

An interesting factor about this anxiety on the part of the seniors, however, was most added a positive frame to their anxiety about how they were going to cope with the concern. Although this, again, cannot be attributed to MFE experience, it is likely that experiences teaching in MFE helped strengthen their efficacy in this way by providing an opportunity to experience coping with struggles in a classroom. Dora and Kendra (seniors) are particularly good examples of this,

> I know that by studying the content and taking time to prepare for the lessons will help me answer student's questions (Dora, senior).

> I am worried that if I do not understand material conceptually, that my students will not be able to master the skills they need to. I do believe that this fear can motivate me into practicing material until I do understand it both conceptually, and procedurally … It scares me that some of the terms I do not know will be information that I need to teach, however I trust that I will master this information as I prepare each lesson (Kendra, senior).

PSTs demonstrated a transition from their sophomore responses, which parallel findings common in the literature about education majors not feeling prepared to do or teach mathematics (Huinker & Madison, 1997), to increased and realistic confidence in their ability to teach mathematics and more student-centered reflections on mathematics as seniors.

PSTs' responses to the qualitative prompts illustrated positive mathematical dispositions and developing personal teaching efficacy. Comparisons between sophomore and senior responses of particular individuals demonstrates growth in perspective from a self-as-student focus to a self-as-teacher focus that is appropriate for having completed two years in a teacher preparation program, but also supports the changes seen within the semester in MBETI scores. PSTs commented on the role of the nature and usefulness of mathematics and how that would shape classroom experiences. The importance of perseverance in mathematics was a factor in many PSTs' excitement to teach mathematics. The role of critical thinking and problem solving were also frequently mentioned in PSTs comments. While general teaching efficacy was not a common theme of responses, personal teaching efficacy was. PSTs were concerned about their ability to help students who struggle in mathematics and especially how to cope with and not create mathematics anxiety in their students. PSTs tended to counter these concerns with specific steps they could take in the classroom. PSTs were excited to experience the effectiveness of their own teaching, having students understand difficult material.

DISCUSSION

Quantitative and qualitative results provide strong evidence to support the claim that an MFE mathematics methods course increases self-efficacy for teaching mathematics and improves mathematical dispositions in PSTs. Over the course of the semester, PSTs' mathematics efficacy and mathematics teaching efficacy significantly increased. There were statistically significant changes in PST responses to nine out of 13 items on MTEBI scale. The qualitative analysis supported these changes, finding evidence of more positive mathematical dispositions from sophomore to senior year. These positive mathematical dispositions were evident in three aspects. The first aspect was increased positive reflections on the nature and usefulness of mathematics and its real-life applications with more specificity about how it related to teaching mathematics. A second aspect of increased positive mathematical dispositions was a focus on the importance of perseverance in mathematics. Finally, PSTs commented in their responses on the active nature of teaching mathematics. Personal teaching efficacy was a common theme of reflection for factors that made PSTs both excited and scared. Increased efficacy was supported by a transition to more concrete fears and comments about how to address those particular concerns.

Our research supports the theoretical framework outlined by Cruz et al. (2019). The mathematical disposition components of *learning of mathematics*, *nature and usefulness of mathematics*, and *perseverance in mathematics* were themes in the qualitative data. Self-efficacy for teaching mathematics included a *personal teaching efficacy* component, which was evident in both the quantitative and qualitative data. We did not observe the *general teaching efficacy* component. It was not a component of the quantitative analysis, nor a theme in the qualitative analysis; it also did not align with the framing of the questions asked.

The findings from this study are consistent with Charalambous et al. (2007) research on factors that affect the development of PST's efficacy beliefs during mathematics fieldwork. Built on Bandura's (1997) work, it identifies four sources postulated to develop teacher efficacy beliefs: *enactive experiences*, *vicarious experiences*, *social persuasion*, and *physiological and emotional arousal*. The MFE methods course leveraged each of the four sources. *Vicarious experiences* are observations of a model engaging

in the task (Charalambous et al., 2007). PST's, particularly those with limited mathematics teaching experience, gained efficacy from first observing the second grade teachers, expert models, and later their peers, models matched on age and perceived experience. *Enactive experiences* are the strongest basis of efficacy of beliefs (Bandura, 1997; Charalambous et al., 2007). *Enactive experiences* occur when a task is completed successfully (Charalambous et al., 2007). In this study, PSTs' lessons to their second grade students were designed to be *enactive experiences*, where the environment was controlled so that PSTs could be successful in their teaching *Social persuasion* refers to feedback given by others (Charalambous et al., 2007). This occurred in the group debriefing with protocols for peer feedback as well as feedback from the faculty. The second grade teachers also sent their feedback to PSTs in an email. The diversity of feedback sources aligns with Bandura's (1997) recommendations for effective social persuasion. *Physiological and emotional arousal* refers to experiencing relaxation, rather than stress, as well as other positive emotions. The seven-weeks spent in the second grade classroom provided PSTs time to become comfortable while also providing multiple opportunities for positive emotions to be felt, such as a student experiencing an a-ha moment.

An MFE methods course provides PSTs with extensive experience in mathematics classrooms both observing and leading. This is a promising approach to develop PSTs' beliefs about mathematics and themselves as teachers of it. The researchers recommend that all elementary mathematics methods courses consider the use of an MFE to build PSTs' self-efficacy for teaching mathematics and improve mathematical dispositions.

The use of MFE in methods courses is in its infancy with the first literature appearing a little over a decade ago (Zeichner, 2010). As such, the significant growth in PSTs' self-efficacy for teaching mathematics, as well as the improved mathematical dispositions, are important findings to direct the development of mathematics methods courses and teacher preparation programs. The authors call for additional research on the metacognitive effects of MFEs on PSTs to add to the field and research best practices for MFE.

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APPENDIX A

2nd Grade Mathematics Lesson Plan (1:45-2:25)

Unit of study: _____

Date: _____

Table A1. 2nd grade mathematics lesson plan (1:45-2:25)

Key idea: (What is the central focus of the lesson?) _____
Essential question**(s):** _____
Content standard(s): Iowa core standards (List number & text of standard. If only a portion of a standard is being addressed, then only list the relevant part[s].) _____
I can statement (learning objectives): (include in PowerPoint to be projected on the smart board) _____
Instructional resources & materials to engage students in learning**:**
Lesson steps: Instructional strategies, learning tasks, & **estimated time** that support diverse student needs (Fill in below. Include what you and students will be doing as well as two-three higher order thinking questions you will pose.) _____
I do: (Time estimate) _____
We do: (Time estimate) _____
You do: (Time estimate) _____
Error analysis: (What mistakes do you anticipate students will make, how will you respond?) _____
Differentiation & planned universal supports: _____
Vocabulary: (What words will be new or newer to students? Are there specific terms that should be used or avoided?) _____
Pre-assessment: (How will you know what knowledge/skills need to be addressed in this lesson?) _____
Formative assessment: (How will you know that students learned the key idea? How will you provide feedback to your students to let them know how they performed on their work during the lesson?) _____
Summative assessment: (How will you know what knowledge/skills need to be addressed in this lesson?) • **Worksheet protocol:** (How will you use the worksheet? How will ensure that all students can/will complete it?) _____ • **Worksheet purpose:** (How will the worksheet inform student mastery? How could it be used to make decision about reteaching or forming RTI groups?) _____
Planning rationale: Think carefully about the decisions you have made in planning this lesson. As often as you can, use research to support your decisions. • How does your understanding of your role, your students' roles, and the purpose of the students' learning impact the design of this lesson? Describe why you chose to instruct in the way you have here. Consider something like this: "Because my 2nd grade students are _____ [like this], I will try to _____ [do this]." • Describe and justify why your instructional strategies and planned supports are appropriate for the whole class, individuals, and/or groups of students with specific learning needs. _____