

MATH ANXIETY IN PRE-SERVICE ELEMENTARY SCHOOL TEACHERS  
AND ITS EFFECTS ON PERCEIVED ABILITY  
TO TEACH MATHEMATICS

by

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## ABSTRACT

The present study investigated math anxiety in pre-service elementary school teachers and its possible effects on their perceived ability to teach mathematics. In researching the causes and consequences of math anxiety, the researcher was interested in the following questions: (a) What are the causes of math anxiety in pre-service elementary school teachers? (b) What contributes to math self-efficacy in pre-service elementary school teachers? (c) What is the effect of math anxiety on pre-service elementary school teachers' perceived ability to teach mathematics? Three pre-service elementary teachers were interviewed in a semi-structured setting. Their responses were then analyzed and coded according to the categories posed by the research questions. The results suggested that timed math tests, high-pressure math assignments, mean math teachers, situations where they felt the teacher was at fault for math struggles, and the cyclical nature of anxiety may have contributed to math anxiety. Self-efficacy in mathematics may have been constructed by positive experiences with math, including teachers who acknowledged the difficulty of math, teachers who made math enjoyable, and teachers who emphasized the process of learning rather than correctness. In regard to future impact on the participants' ability to teach math, the participants spoke about avoidance of math in their own lives, the value of resilience in teaching and learning math, concern over modeling math anxiety for their students, changed perspectives because of pre-service teacher training, and uncertainty of how to make their students feel comfortable with math.

## MATH ANXIETY IN PRE-SERVICE ELEMENTARY TEACHERS

### Math Anxiety in Pre-service Elementary School Teachers and its Effects on Perceived Ability to Teach Mathematics

It is common today to hear college students say they are “not math people” or they have never liked math (Jackson & Leffingwell, 1999; Furner & Duffy, 2002). Anxious feelings toward mathematics seem to be more prevalent than anxious feelings toward other core subjects (Helwig, 2004). Helwig (2004) conducted a longitudinal study, which found students selected math as their least favorite subject every year from second grade through 12<sup>th</sup> grade. With the current push for U.S. students to pursue careers in science, technology, engineering, and math, it is important to investigate why so many students seem to have anxiety in relation to mathematics. One possibility is that students are modeling these negative feelings after their teachers’ negative feelings toward mathematics. Bandura & Rosenthal (1966) found that even if observers have a neutral reaction to a particular stimulus, they might learn to react negatively by observing others experience negative reactions toward said stimulus. In the field of teaching specifically, young students have shown a tendency to imitate their teachers while performing work on their own (Bandura, 1966). This may start as early as elementary school. The purposes of the present study are to investigate math anxiety and math self-efficacy in pre-service elementary school teachers and their effects on their perceived ability to teach mathematics.

#### **Literature Review**

Math anxiety is sometimes defined as “a feeling of nervousness, unease, or tension that interferes with math performance” (Chernoff, 2014, p. 29). Another author defines it as a feeling of unease and fear that surfaces when one engages with activities related to math (Wang et al., 2014). In some individuals, this anxiety is so strong that the anticipation of doing math-related tasks triggers a reaction in the brain similar to that of physical pain (Lyons & Beilock, 2012).

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Students may experience sweating, increased heart rate, nausea, panic, stomach discomfort, and more (Chernoff, 2014). Individuals with high math anxiety also have a strong desire to avoid math and math-related activities. This anxiety can cause “mental disorganization” and may make it more difficult for individuals to process information related to math (Ashcraft, 2002; Tobias & Weissbrod, 1980, p. 65).

Current research shows a link between math anxiety and self-efficacy in math. Bandura (1993) defines self-efficacy as one’s belief in his or her ability to achieve a goal. His research shows that one’s ability to achieve this goal is directly related to one’s self-efficacy. Bandura’s (1993) research indicates students believe anxious feelings toward a certain task are a sign that they will be unsuccessful. Further, those who doubt their self-efficacy in a given area tend to visualize instances in which they will experience failure, which in turn leads to anxiety (Bandura, 1993). Additional studies show similar findings in that students with higher math anxiety believe they are less efficacious in solving math problems. Griggs et al. (2013) found that higher anxiety in any subject area leads to lower perceived self-efficacy in that area. In regard to math specifically, Bandura (1993) found that a student’s positive attitude toward the subject is a better indicator of that student’s performance than his or her math ability. Another important factor that Bandura (1993) claims may lead to anxiety is seeing others surpass oneself.

Math-anxious individuals tend to avoid college majors and careers that relate to math (Ashcraft & Krause, 2007). This is especially concerning in the case of pre-service elementary teachers; they may unwittingly choose a career path that requires deep understanding and engagement with math. A study by Ball (1990) found that, in a group of pre-service elementary teachers, less than half felt that they were capable of understanding advanced math. Over a third of them said that they were not good at math and tend to avoid math altogether. Another study

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showed that pre-service elementary teachers tend to have low math self-efficacy (Merkowsky & Chernoff, 2014). Pre-service elementary teachers have reported high levels of negative perceptions of math; in Burton's (2015) study, 52% of the pre-service elementary teacher participants reported having a negative perception of math, while only 14% reported having a positive perception.

Tobias's (1991) research and experiences working with undergraduate students showed that most students indeed have the cognitive ability to excel in even advanced math courses. She emphasized the key effect that experiences have on students; when students feel out of control of their own learning or embarrassed in front of their peers, or have a particularly negative experience with a math teacher, they tend to associate these negative feelings with the subject of math in general. Fiore's (1999) study had similar results: teachers, especially in the elementary school setting, appeared to have a significant impact on their students' feelings toward math, and therefore the students' success in math. It seems that math anxiety is more closely related to the way teachers and parents present math than it is to the nature of the math itself (Greenwood, 1984; Lazarus, 1974).

### **Method**

#### **Research Questions**

In researching the causes and consequences of math anxiety, the researcher was interested in the following questions: (1) What are the causes of math anxiety in pre-service elementary school teachers? (2) What contributes to math self-efficacy in pre-service elementary school teachers? (3) What is the effect of math anxiety on pre-service elementary school teachers' perceived ability to teach mathematics?

#### **Participant Demographics and Recruitment**

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The participants (n = 3) were selected through purposeful homogeneous sampling (Coyne, 1997). Pre-service elementary school teachers enrolled in two sections of their first elementary mathematics education course (n = 61) were asked to complete a survey to determine their self-reported levels of math anxiety from 0 to 10, with 10 being the most math anxiety. Twenty-six survey participants reported a math anxiety level of five or higher. Of these 26, nine indicated that they were willing to be contacted for individual one-hour interviews. The researcher invited these nine individuals to participate in an interview via a scripted email. The researcher received responses from three individuals, who were then interviewed. A copy of the survey can be found in Appendix A.

**Participants.** Each participant was a female in her early 20's and a college junior at the time of her interview. Abigail, Beth, and Caroline reported a 7, 5, and 5 out of 10, respectively, on their initial math anxiety surveys. Abigail identifies as Chinese/white, and the other two participants identify as white. The participants came from middle- to upper-class backgrounds. Abigail and Caroline attended public schools from kindergarten through 12<sup>th</sup> grade, while Beth attended private school for her whole life. All plan to teach elementary school after graduation. Caroline is considering pursuing her master's degree in an accelerated master's program with an emphasis on special education. Each participant's teaching experience is limited to short-term field experiences through their teacher education programs. Abigail also had experience teaching at an after-school program that supported students in science, technology, engineering, and math (STEM) skills.

### **Setting**

The setting for the present study is the College of Education in a selective, private liberal arts university located in an urban metroplex in the southern United States. During the year of

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the study, university enrollment was reported as approximately 9,000 undergraduate students, approximately 300 of whom were members of the College of Education. Approximately 60% of enrolled undergraduates in all programs were female, 72% were white, and 52% were native to the state in which the university is located. The three participants are representative of these demographics. The university is affiliated with a specific denomination of Christianity, but being personally affiliated with this denomination is not a requirement to attend the university.

### **Procedure**

**Data sources.** The sources of data were three, 45 minute, semi-structured interviews—one with each of the three participants—conducted during the fall semester of each participant’s junior year of college. To provide the interviews with structure, the researcher created five different topic domains that were based on the research questions. The researcher composed several open-ended questions within each topic domain, with additional follow-up questions. For example, to investigate the causes of math anxiety in interviewees, the researcher asked flexible, non-leading questions such as “What are some of your earliest memories of math?” The researcher then asked impromptu follow-up questions as needed to gather additional information.

The interview protocol was based on the critical epistemology of Carspecken (1996). The researcher linked specific covert categories to each topic domain and used these categories to help guide the conversation during the interview. For example, the researcher asked the question “When you picture yourself teaching math, what does it look like?”, and expected responses would fit into the following covert categories: anxiety about teaching math, comfort level with teaching, relation of math anxiety and general teaching anxiety, and desire to prevent math anxiety in future students. The researcher was aware of the possibility that results might

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not fit into any anticipated covert category and that new categories might surface during data analysis. A sample of the interview protocol can be found in Appendix B.

The researcher transcribed each interview verbatim and used the transcriptions for data coding. The researcher strove to capture each participant's unique voice in the transcriptions while deleting filler words including, but not limited to, "like" and "um". The researcher also changed the name of each participant to a pseudonym and altered the names of any identifying people, places, or organizations mentioned in interviews to maintain anonymity.

**Data analysis.** The researcher used analytical procedures guided by Carspecken's (1996) critical epistemology. The researcher assigned low- or high-level codes to selections of data from the interview transcriptions. The low-level codes were generated by an iterative process in which the researcher categorized quotes into groupings that aligned closely with the original data source and the research questions. The researcher based these categories on the literal interpretation of what the participants said, and did not solidify the low-level codes until all three transcriptions were completely coded at this level.

Next, the researcher found emergent themes after further analyzing the low-level codes document. These themes were organized into high-level codes that aligned with researcher inferences and high-level interpretations of the data through the lens of the research questions. The researcher engaged in one session of peer-debriefing with a peer researcher; the main researcher randomly chose one low-level code for the peer to analyze independently. The researcher and peer compared high-level analysis to see if they were in agreement. No significant differences were found. As a final step, the researcher sent the transcriptions to each participant via email attachment and asked if there was anything they wanted to add, change, or clarify. The researcher received responses from two out of three participants. These two

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participants said no changes were necessary. The third participant did not respond after multiple attempts at contact. A sample of low- and high-level coding can be found in Appendix C.

After organizing all the collected data in the aforementioned manner, the researcher synthesized the high-level codes into a cohesive report, to be found in the results section of the study.

**Study limitations.** One limitation of this study is that the last ten minutes of Caroline's interview were lost due to a technical malfunction. The section of the interview that the researcher lost was the section in which Caroline and the researcher spoke about Caroline's visions of future teaching. Another limitation of this study was that the researcher only interviewed each participant one time. While analyzing the transcriptions at different levels of coding, the researcher noted several instances in which it would have been useful to ask the participant follow-up questions.

### Results

#### **Research Question 1: Causes of Math Anxiety in Pre-service Elementary Teachers**

When asked about early memories of math in school, the participants highlighted five kinds of negative experiences: (a) timed math tests, (b) high pressure math assignments, (c) memories of mean math teachers, (d) situations where they felt the teacher was at fault for their math struggles, and (e) a cycle of anxiety.

**Timed math tests.** When the researcher asked each participant about math-related activities from elementary school that they disliked, the first thing all three participants said was "times tables" or "times tests", in reference to tests about basic multiplication facts. For Abigail, the issue was being slower than other students or her sibling; for Beth and Caroline, the presence of the clock itself created a feeling of pressure. Abigail responded this way:

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I did terrible on [times tables]. I'd go home and I'd have to practice with my mom and dad, and my little sister would be saying the answers to the flash card things. [My mom] would be like "5 times 2" and my sister, who's two years younger, knew the answer and I'd be like "wait, I know that one!" It always took me a second longer than she did.... I remember sitting there trying to figure them out, and having to either count on my hand—for the addition I had to use my hands, or draw little pictures, and you obviously can't do that for every one; you're not going to finish. So, I very very rarely finished, and I would repeat the same quiz over and over again. It was just—everybody else was finished, or they'd finish before the minute or two minutes or whatever it was, and I was like, "how are you finished? I'm on my first column."

Caroline also recalled taking longer than most of her classmates to pass the times-table tests:

The times tests. I remember hating those.... I remember not accelerating as well on the times tables and passing them like everyone else did. It wasn't because I didn't know them. I just feel like it was because it took me longer to process the problem and move on to the next one. I remember I would never get any of them wrong, I just would never finish them.

Beth noted that she "didn't like times-table tests" and that she believes "everyone just feels rushed" while taking them.

**High-pressure math assignments.** Another source of math anxiety for all three participants was assignments they perceived as having a large effect on their future academic trajectory or reputation. Beth's response exemplifies this theme. She recalled the "mastery tests" she had to take at the beginning of every school year. These were based on objectives the students were expected to study over the summer to maintain their skills across all subjects. She had a hard time passing this test and explained how it impacted her confidence:

At the beginning of the school year, we had mastery tests...and you had to get an 85 or above. You had to keep taking it and keep taking it and keep taking it until you passed it. That wasn't fun.... I feel like everyone knew if you hadn't passed it yet. So, you just had to keep taking it.... One year I think it took me like seven times. So it sucked.... Just knowing that you *had* to pass it. That you *had* to get a certain score or else.

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Beth did not feel this kind of pressure for every test, though; it was not testing *per se* that caused the anxiety. “Hard” tests that had little impact on her grade did not cause the same anxious feelings.

Abigail and Caroline were more concerned with embarrassment. Abigail was embarrassed that her younger sister was surpassing her in math classes. Caroline spoke about her fear of doing math in front of her peers:

I would always go into class and be nervous if [the teacher] were to call on me or to have to work out a problem on the board. Even though I could do it on paper, I would just get nervous in front of people that I would do it wrong. I always liked numbers and that kind of thing, but I guess [I] just had anxiety and [it led me to] maybe not do as well.

**Memories of mean math teachers.** Another theme that materialized under this heading was a vivid memory of a mean math teacher. Each of the three participants remembered a specific math teacher or interaction with a math teacher that left a sour taste in her mouth. Beth remembered a math teacher from high school that embarrassed her in front of the class:

God, she was so mean. I think I did bad on something and I wasn't paying attention. She said, “you're going to fail this class.” She said it in front of the entire class and she had to apologize to me. She got in trouble. It was awful. Having a teacher like that made you not really like it.... If you weren't paying attention, she was really rude. I'm always writing in my planner, and she would take it away from me and put it on the windowsill.

Abigail vividly remembered a teacher that she disliked as well:

[My sixth grade teacher] definitely was the worst math teacher I've ever had. She was very traditional in her ways, and she had one of those overhead projectors that she would write on. Then she'd lick her finger, and clean it off, and then she'd lick it again and there'd be marker all over her face. It was terrible. She had a desk in the back of the room that had her imaginary friend in it, and it was a historical desk that I always wanted to sit in and it was really cool. If you sat in it you'd get detention. She was very strict, and she just—she'd always get me in trouble, and was like “you're talking while I'm talking” and I was like, “I'm asking him because I don't know how to do it”.... I remember when we were getting rid of remainders, and she literally threw pieces of paper out the window. She was like, “we're throwing out remainders” and

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threw them out the window and we were like, “you’re crazy”. So, yeah, she was just very crazy. It did not help having her in 6th grade because I didn’t get any of the basics of middle school math, I guess.

Caroline worked very hard on a project in sixth grade, but did not receive any credit once it was graded. She remembered the project itself, and the feeling she had after receiving her grade:

[A project] I did—it was wrong, but I spent so much time on it, and I remember to this day that I didn’t get any credit on it. I organized order of operations wrong, so she didn’t give me any credit and it took me so long. She just never really encouraged me. I was always wrong ... to her.

**Teacher is perceived at fault for math struggles.** A related theme that emerged was an external locus of control among the participants. They often placed blame on teachers for their poor performance in math class. Most of Beth’s examples of blaming the teacher came from an experience in her college statistics class. The professor chose to let his teaching assistant (TA) grade papers, and many of the students were unhappy with this decision. Beth described it this way:

His TA would grade ... stuff that he didn’t do that way or he didn’t ask us to do that way. Everyone would get so frustrated because we’d be counted off for stuff we didn’t know we were doing wrong.... The homework was graded on stuff that he didn’t say or tell us to focus on, so we didn’t know how the tests were going to be.... We would beg [the professor]: “you have to grade the tests. The TA isn’t in here, she doesn’t know what you’re teaching.”.... I was like, “I don’t know how to understand this if you’re not telling me how you’re doing this.” So, just the way he taught in general ... made me feel anxious.

Abigail blamed a particular middle school teacher for her lack of success. She remembered one instance very clearly:

She once graded my paper, because we took a test or whatever, and her answer key was wrong. So, I had gotten it right, but then she told me it was wrong, so I thought it was wrong, and I psyched myself out so bad. So she was just not good.

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Abigail also described instances in which she felt anxious because the teacher did “not [do] anything to make [her] feel comfortable in the class.” Caroline talked several times about solving problems in different ways and how her teachers rarely let her do it in the way that she understood. She described it in this way:

I would always get the right answer, but I didn't [do it their way]. They would always count off, so I think that's why I never did as well as I could've. I'd get the right answer, but I wouldn't show it like they wanted me to.

**Cycle of anxiety.** The final theme the researcher found related to causes of math anxiety was a type of “snowball effect”, or a cyclical nature of struggling in math. The researcher asked Beth what she wished her teachers had done for her while in school:

Wait time. A lot of the time the teacher would ask a question or put a problem up, and the kids who were really fast and good at math and could do it really easily without any problems would get done faster. Then the teacher would be like, “okay, who has the answer?”, and the kids who weren't done would just stop working on it. It's like a cycle. Only the kids who do it fast enough can talk. Then you don't finish working on the problem and you don't get it.

Abigail described how the cyclical effect occurred outside of class. Since she often struggled to learn concepts as quickly as her classmates, her parents would try to help her at home:

So a lot of the time, if I didn't finish something in class, I'd have to bring it home. So I was doing homework a lot, and, in some ways, it helped because it gave me extra practice with my parents. They had a different way of explaining things than the teacher did. So it helped, but at the same time, I did a lot of math homework because I didn't finish the worksheets that we did in class, or whatever.... My parents would try so hard with me to get it into my brain and eventually I did get it. I was able to pass to the next section. But by then we were doing double-digit numbers, and that was really hard. It just—the times-table thing—that was so exhausting and hard for me.

Caroline also shared a story about how her struggles in one section of geometry affected her performance in later units, noting the importance of understanding a fundamental concept.

I struggled with line AB and segment whatever. It was in relation to that. I was really struggling with it. I didn't do well on the test. I needed to know [the things from that class] to understand the following concepts, so it was really important concepts.

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Although the participants didn't explicitly mention anxiety or fear very often during their interviews, it was evident to the researcher that talking about these events in their pasts still brought about noticeable discomfort. The participants would speak faster when talking about types of math with which they were not successful in their earlier years of schooling. They also would adjust their seating or alter their body language when talking about these events; these seemed to be physical expressions of mental discomfort.

### **Research Question 2: Math Self-efficacy in Pre-service Elementary School Teachers**

When asked about teachers who made math feel comfortable or more accessible, the participants spoke about three types of teachers: (a) teachers who acknowledged the difficulty of math, (b) teachers who made math enjoyable, and (c) teachers who emphasized the process of learning rather than correctness.

**Teacher acknowledges math is difficult.** The first of these themes was having a teacher who acknowledged that math is difficult for many people. Beth had a teacher when she was in 12th grade who changed her views about math; she "hated math" until she had this teacher. The teacher told her students to forget everything they thought about math and to start with a blank slate. Beth appreciated this advice and ended up enjoying math class that year. Abigail also had teachers that admitted math was either hard for them personally or hard in general. She liked this transparency with her teachers because she "got to relate" to her teachers. Abigail remembered her fourth grade teacher specifically, and described her this way:

[My favorite math teacher was] probably my 4<sup>th</sup> grade teacher, because she just was like, "I hated math, but you can learn and love it one day too." So even now, when I'm struggling in math, I'm like "okay, I'm gonna keep trying. It's a challenge but I'm gonna keep trying, because it's okay to hate it, because at the end you might like it. And become a math teacher."

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Abigail said it was “really helpful” to have teachers who encouraged her and who helped her understand “it was okay that [she] wasn’t the best at math.” She described fond memories of her fifth grade teacher exercising patience when teaching her.

**Teacher who made math enjoyable.** Another theme that emerged under this heading was having fond memories of a teacher who made math enjoyable. Each participant was happy to share a specific story about her favorite math teacher from elementary, middle, or high school. Beth again spoke about her 12<sup>th</sup>-grade teacher that made her enjoy math for the first time. Beth said that her senior year in high school was “the only time” she ever liked math. She described her teacher as “really relatable and not scary; she didn’t seem like she was the instructor.”

Abigail recalled specific projects and teaching techniques that she liked while in school. One of her teachers taught fractions on the board using multiple colors. She “liked it because it was all color-coordinated” and noted that her teacher “explained it in a way that was different than everybody else had.”

Caroline’s favorite teacher “understood that everyone could solve problems in different ways” and was the first of her teachers to have this understanding. Caroline often had points counted off on her math assignments because she solved problems differently than the teacher wanted her to, even if she still got the correct answer. When the researcher asked Caroline what made her favorite teacher such a good teacher, Caroline responded this way:

I really liked my geometry teacher in high school, but I hated geometry. She was a really good teacher.... She just knew everything. She would never stumble on a question that was asked.

She also appreciated professors in college who were “willing to give a ton of time to students” and were able to “adapt to [her] type of thinking.” She recalled a time that she went into office hours for one of her math professors and the professor “took the time to realize how [Caroline] thought” to the point that she “completely understood it and was not frustrated.”

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**Emphasis on process versus correctness.** The final theme that emerged under this heading was a discussion about emphasizing the learning process versus emphasizing correctness. The participants had differing views about this theme and described the style of teaching they most enjoyed while in school. Beth enjoyed math more when she had a teacher who didn't emphasize correctness. She described her experiences with her professor this way:

I like [math] now because [of] the teacher I have. It's not about getting it right. You don't have to get it right. He just wants to know how you're thinking about it so he can help you understand it better. So on our homeworks, if we explain our process and everything, we get full points for that even if it's wrong. The way he teaches is that there isn't any wrong answer.... I think it just makes you feel more comfortable. If you're not really grasping a concept, he'll be able to know based on what you wrote. He'll be better able to help you.

Beth also said that she thinks a student who is taught in this way will not be scared to try a problem out of fear of getting the wrong answer. She thinks that a student "wouldn't have anxiety about working on" math problems because "there's no wrong answer."

Abigail described scenarios when she experienced anxiety about getting the right answer. She also talked about trying to memorize formulas and other math processes without having a deep understanding of the math behind the formulas. She said that she "didn't know why" she needed to use a particular formula, but rather that she just knew the formulas well enough to use them. This emphasis on learning just enough to do well on a test did not serve her well in math class. Caroline also talked about the time when she realized that pure memorization is not a form of studying that promotes genuine understanding. She said she "learned that, instead of memorizing the information," she should start "trying to understand it." This kind of studying reduced her stress because she realized that, if she "understood the concept," she "[would] not mess up."

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Unlike Beth, Caroline said that explaining the process of how to do a problem gives her “a lot of anxiety” because it is hard for her to explain how she does math problems. She had a professor that gave problems with only one answer and he let her work out the problems however she wanted. She “really liked” that he cared more about his students “getting the right answer” than solving the problem a particular way, so she “usually did really well in that class.”

### **Research Question 3: Effect of Math Anxiety on Pre-service Elementary School Teachers’ Perceived Ability to Teach Mathematics**

For the final research question, the researcher examined the impact of math anxiety on a pre-service elementary teacher’s perceived ability to teach mathematics. Five major themes emerged under this final heading: (a) the participants avoid math currently, (b) they value resilience in their students, (c) they are concerned about modeling math anxiety for their students, (d) they have a changed perspective because of pre-service teacher training, and (e) they are unsure of how to make math comfortable for their students.

**Avoidance of math.** One prominent theme was a purposeful avoidance of math. All three participants described times in their current lives when they avoided math. Beth laughed when the researcher asked if she had taken any math courses in college that weren’t required, saying that she tries to “steer clear of math” when it’s not required. Abigail said that she “[does] not really enjoy doing” math problems in her elementary math course. When asked about her future plans, Abigail said, “I don’t see myself becoming a math teacher, or [rather], solely a math teacher.” Unlike the other two participants, Caroline was not as quick to avoid math. She said that she would consider taking a math course in college if she had enough time in her schedule.

**Value of resilience.** Another theme that arose was the value of resilience in teaching and learning mathematics. The researcher asked all participants what values they would like to

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promote in their classrooms. Beth does not want her students to be afraid of trying new things or getting wrong answers; she wants them to learn from their mistakes. Beth described the resilience she would like to promote in her students:

I feel like, not being scared to try something just because they think they might not get it right. That's the only way the teacher will know where they're at.... If they don't try it, even if they get it right, then [the teacher] won't know anything.

Abigail spoke both about values she wants to instill in her students and values that she wants to have herself. For her students, Abigail wants to promote persistence by modeling it. She admitted that she is nervous about teaching math. Abigail wants to have transparency with her students, and model how to push through something that is difficult or confusing:

I'm sure in the regular day when we go to math, that definitely won't be my favorite part of the day, but it's still a part that needs to be taught. They need to know math. I'll have to be like, "I'm not going to teach it to them wrong", and if I do then that's okay. I can teach it to them in a different way that's correct. I'm sure [math anxiety] will be there and I'll be a little anxious, but it's not the worst thing. I don't think I'm going to be so anxious that I'm not going to be able to do it.... I'm going to be really positive and not let them see that this is something that is not my favorite thing in the world, but it's still something that I'm going to try and do the best that I can. I want them to do the best that they can.

**Concern over modeling math anxiety.** An additional theme that emerged was concern that the participants were modeling math anxiety for their students, and that perhaps this fear would transfer to the students themselves. All three participants expressed a specific desire to teach in ways that avoid this outcome. Beth described it this way:

I feel like, if I'm nervous about it and nervous about what I'm teaching, then they will sense that and be not as comfortable [with math] as I'd want them to be.... If I'm anxious about it, they're going to be anxious about it too.

She went on to explain the importance of being proactive in her classroom about recognizing math anxiety before it gets severe. Abigail had similar desires. She adamantly expressed that she does not want her students to grow up having math anxiety. She feels pressure to make sure that her students have a more positive experience with math than she had:

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My math anxiety—it stayed with me. It was with me forever, all through school, and it still is. So if I can help prevent it then, in elementary school, then they don't have to deal with it. I don't want them to have to always be second-guessing themselves and thinking that they're wrong. Because most of the time they probably aren't even wrong.... I know it's challenging, but for my students—my future students—I want to understand [math] so they can understand it.

**Changed perspective because of pre-service teacher training.** Another major theme that came up was that pre-service teacher training in math changed the participants' view of math. Beth admitted that she had not liked being called on in class when she was in elementary school, but now has a new perspective:

I don't like being called on, but I feel like that's a better way to teach—to have other people talk about how they found their answer. It's better for people to hear their peers say "I did it this way" as opposed to the teacher being like, "do it this way."

Beth also said that she didn't feel like she was good at math "for the majority of when [she] was in school." She immediately followed that statement with her thoughts on how those feelings would affect her future teaching style. By teaching with the viewpoint that there are "no wrong answers" in math, Beth hopes to alleviate some of the pressure her future students might feel.

Abigail talked at length about providing opportunities for one-on-one interaction with her future students. Because projects helped her understand material and allowed her to be creative at the same time, she wants to incorporate projects into her future classroom. Abigail wished she could have gotten more one-on-one help while in school, so she hopes to be able to provide individualized help to her future students as well. She described how her math anxiety has impacted her life:

I don't want them to hate math how I did, because that's something that you—you have it for the rest of your life. Whether you have good teachers or bad teachers, it keeps coming back.

**Unclear picture of how to make math comfortable.** Another theme that the researcher found was an unclear idea of how to help future students feel comfortable doing math. Beth said

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that she does not “know how to make them excited about math.” She believes it is important for the teacher to be “conscious and aware” of what he or she is asking students during math lessons, but seemed uncertain of her ability to ask useful questions to probe her students’ thinking. She hopes it will “become second nature” and that she will develop her questioning skills in the future.

Abigail taught at an after-school program that focuses on science, technology, engineering, and math. She said that she does not typically feel nervous when she is teaching those subjects to the program participants and is able to explain things clearly. While she enjoys teaching algebra, she gets nervous when thinking about teaching elementary math. She feels anxious when she is trying to decide the best way to teach math to elementary-aged students. She explained that perhaps it is just basic math that makes her so nervous:

It’s weird because, maybe it’s just the basics that make me nervous, because that’s what I had problems with when I was in elementary school, but I can teach the upper grades about math.

In summary, the participants had early memories of negative experiences with math associated with timed math tests, high-pressure math assignments, mean math teachers, situations where the teacher was perceived to be at fault for their math struggles, and the cyclical nature of anxiety. Their self-efficacy in mathematics was constructed by positive experiences with math, including teachers who acknowledged the difficulty of math, who made math enjoyable, and who emphasized the process of learning rather than correctness. Finally, the participants spoke about the effects they believe their math anxiety will have on their future ability to teach math. They spoke about avoiding math in their own lives, valuing resilience in teaching and learning math, concern over modeling math anxiety for their students, changed perspectives because of pre-service teacher training, and an unclear idea of how to make their students feel comfortable with math.

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### Discussion

This study investigated the development of math anxiety, math self-efficacy, and teaching self-efficacy in pre-service teachers by analyzing the pre-service teachers' past, present, and potential future experiences with math. Despite the fact that the participants' self-reported math anxiety survey results were not particularly high (7, 5, and 5 out of 10, respectively), they all described many situations in which their math anxiety prevented them from being successful in math and how they anticipate it will affect their teaching. The participants were eager to talk about their past experiences with math and describe stories of their teachers in their formative years. The data suggest that math anxiety can develop in response to stimuli during a student's early years of learning math. The participants also seemed to develop confidence in math as a result of having a supportive or encouraging teacher in their early years of schooling. The participants' descriptions of their math anxiety paralleled those found in preliminary research (Ashcraft, 2002; Chernoff, 2014; Lyons & Beilock, 2012; Wang, 2014). Because of the potential for elementary school teachers to transmit their math anxiety to their students, the lasting effects of math anxiety in pre-service teachers are all the more crucial to evaluate (Lazarus, 1974). Pre-service teachers who experience math anxiety are of particular interest because they have the unique ability to recognize and address math anxiety in themselves before interacting with young learners.

In regard to the first research question ("What are the causes of math anxiety in pre-service elementary school teachers?"), the data suggested two general causes. The first was an emphasis on timed tests and high-pressure tests during elementary school. All three participants had vivid memories of disliking these types of tests. Most specifically, the participants all spoke of stressful memories linked to the multiplication-table tests that most students take during third

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grade. The participants associated poor performance on these tests with lack of skill in mathematics. They recalled getting correct answers on the questions that they completed, but not finishing the tests in time. Because of their young age at the time, the participants assumed they were simply not good at math based on the scores on their tests. They did not understand the difference between unfinished answers and incorrect answers. Perhaps the emphasis on this type of testing puts unnecessary pressure on young learners who cannot yet adequately manage stress (Thompson, 2014). The mindset that a poor score on a single test indicates insufficiency in math could be detrimental for young students because such a mindset can have lasting effects. The participants in the present study reported that they anticipate they will have math anxiety for the rest of their lives despite efforts to combat it.

The research suggested that additional causes of math anxiety might be an apparent external locus of control or lack of resilience in young students. The participants all placed blame on their teachers for poor performance in math at some point in their school careers, and each told stories of times that they did not feel in control of their own learning. These feelings turned into a cycle from which they could not escape. The pattern seemed to develop in the following way: the student did poorly on a math assignment; the student had negative interaction with her math teacher that led her to blame her poor performance on the teacher; the student no longer felt in control of her own success; and, finally, the student felt helpless in math. Descriptions of some variation of this cycle appeared in the data collected from all three participants. Once the student felt like she lost control of her own learning or her ability to be successful, she started to view success in math as an impossible feat. Often, the students developed this view because they put in effort seemingly to no avail. Students who try hard at a

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mathematical task and still fail have the potential to grow up with the view that they cannot learn mathematics (Hannula & Lehtinen, 2005).

The cyclical nature of math anxiety is not a new discovery. Other studies have shown results in which participants expressed feeling trapped in a cycle of sorts (Baroody & Costlick, 1998; Shore, 2005). Understanding this cycle is crucial in order to prevent math anxiety in young learners. A teacher who has experienced this cycle is uniquely qualified to recognize it in his or her students. Teaching metacognitive strategies to young students could be helpful to break this cycle. Metacognition helps students become aware of the “capacities, limitations, and peculiarities of the human memory system” (Kreutzer, Leonard, & Flavell, 1975, p. 2). A study by Kreutzer, Leonard, & Flavell (1975) found that children may start to demonstrate use of metacognitive strategies as young as kindergarten, and begin to develop greater understanding of these strategies around third grade. Because the participants of the present study first described math anxiety occurring during their third-grade year, it is likely that metacognitive strategy intervention would be both effective and beneficial as early as third grade. Students should know at a young age that they have the power to control their own learning. Metacognitive strategies are one way to help students reflect on their own learning and make decisions about their studies, even at the elementary level.

The second research question (“What contributes to math self-efficacy in pre-service elementary school teachers?”) revealed one major theme: a teacher who acknowledges the difficulty of mathematics helps students feel more efficacious in math. All three participants enjoyed having a math teacher who admitted the difficulty of math and encouraged them to persist in their studies despite the challenges that math presents. This may be a bit counterintuitive. In the traditional school setting, a social norm exists which dictates that, in

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order to establish credibility, a teacher should not admit to struggles or uncertainty (Stipek, Givvin, Salmon, & MacGyvers, 2001). The present study suggests that a teacher who admits to having struggles in math can more easily relate to students with similar struggles. This also gives the teacher the opportunity to model how to overcome fear of mathematics.

The results of the third research question (“What is the effect of math anxiety on pre-service elementary school teachers’ perceived ability to teach mathematics?”) are crucial to determine the implications of this study. In traditional classrooms, students who typically do well in math and perceive themselves as successful in math are good at memorizing facts and procedures, but often have limited conceptual understanding (Huinker & Madison, 1997). This may be due to the fact that traditional classrooms place an emphasis on drill, timed tests, and memorization (Chernoff, 2014). The interesting link stems from this: teachers with high math anxiety themselves tend to retreat to traditional teaching styles rather than adhering to current best-practice guidelines (Bandura, 1993). Teacher efficacy is important in determining the climate of a classroom. Huinker & Madison (1995) define teacher efficacy as having two components: personal teaching efficacy (the belief in the effectiveness of one’s own teaching) and outcome expectancy (the belief that one’s teaching will influence learning). Teachers with low personal teaching efficacy have anxiety toward teaching itself, whereas low outcome expectancy can lead to apathy and an attitude of learned helplessness in teaching. The participants in the present study indicated that they had a desire to try the progressive teaching methods they learned in their elementary mathematics education classes, but expressed fear of not being able to successfully implement these methods. These participants may revert to traditional teaching methods if they find that the new methods they learned are too difficult to

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execute. There is still work to be done in teacher education programs to create a deep level of understanding among pre-service teachers of progressive teaching methods and their benefits.

However, the results of this study are also promising for the mathematics teaching community. The participants acknowledged that their math anxiety would still be present when teaching elementary-level math, but they also felt that they would be able to be effective teachers in spite of it. The participants collectively felt pressured to teach math well and to prevent math anxiety from occurring in their students. While there is the potential danger of transmitting math anxiety from a math-anxious teacher to a student, these pre-service teachers realize that they are uniquely qualified to recognize and prevent math anxiety in their students. They have a sense of duty to save their students from experiencing a similar fate to their own in regard to math. Because of the potential transfer, pre-service teachers carry a responsibility to address their math anxiety before entering the classroom. The benefits of this are three-fold: it will make the transfer of math anxiety from teacher to student less likely, it is likely to improve the teachers' math teaching efficacy, and it will help teachers learn ways to address math anxiety in their students.

The present study suggests the participants, and other pre-service teachers with math anxiety, are not necessarily at a disadvantage. When teachers can recognize the signs of math anxiety in their students, take steps to combat this anxiety with methods that have worked in their own experience, and model resilience in their teaching, students are likely to respond positively and believe that they are able to learn math. Perhaps teachers who have experienced math anxiety themselves are the best candidates to prevent math anxiety in young students.

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Appendix A

**What is math anxiety?**

Math anxiety is sometimes defined as a feeling of nervousness, unease, or tension that interferes with math performance. It can also be described as a feeling of unease and fear that surfaces when one engages with activities related to math. Students may experience sweating, increased heart rate, nausea, panic, stomach discomfort, and more. Individuals with high math anxiety also have a strong desire to avoid math and math-related activities.

Please circle your general level of math anxiety below. 0 means that you do not ever experience math anxiety. 10 means that you always experience severe anxiety when doing math.

0      1      2      3      4      5      6      7      8      9      10

If you would be willing to be interviewed about math anxiety, please provide your contact information below:

Name: \_\_\_\_\_

Email: \_\_\_\_\_

Phone: \_\_\_\_\_

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### Appendix B

#### TOPIC DOMAIN 1: DEMOGRAPHIC INFORMATION

1. Describe yourself:
  - a. Age
  - b. Gender M F
  - c. With what racial identity or racial heritage do you identify?
  - d. What is your major in school? Have you ever changed your major?
  - e. What is your year in school?
  - f. Did you transfer from anywhere else?
  - g. How would you describe your family's socioeconomic background?
  - h. Did you go to private or public schools K-12?
  - i. What math courses have you taken here at [university]? /What are you taking now?
2. What are your career plans after graduating from [university]?

[covert category: racial identity, decision to choose teaching, future teaching goals]

#### TOPIC DOMAIN 2: MATH ANXIETY IN PAST EXPERIENCES

1. Tell me about your math classes in elementary school.
  - a. What are some of your earliest memories of math?
  - b. What kinds of activities did you enjoy?
  - c. What kinds of activities did you dislike?
2. Tell me about your math teachers in school.
  - a. Who was your favorite? Why?
  - b. Who was your least favorite? Why?
3. Tell me about a time in the past (if any) that math made you feel anxious.
  - a. Do you have any other examples?
  - b. What about elementary school? Middle school? High school?
4. Tell me about time in the past (if any) that you really enjoyed doing math.
  - a. Do you have any other examples?
  - b. What about elementary school? Middle school? High school?

[covert categories: developing math anxiety, origins of math anxiety, activities that cause/relieve anxiety, styles of teaching that promote/relieve anxiety]

#### TOPIC DOMAIN 3: PRESENT MATH ANXIETY

1. Tell me about your experiences with math in college.
  - a. Why do you take math classes in college?
  - b. Have you taken any math courses that were not required of you? (Why/why not?)
  - c. You've told me that you took X,Y,Z math courses. Some of these have been here in the College of Education, and others in the Math department. Have these felt different to you in any way?
2. Tell me about a time in college (if any) that math made you feel anxious.
  - a. Do you have any other examples?
3. Tell me about a time in college (if any) that math made you enjoyed?

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- a. Do you have any other examples?
4. Tell me about your math/math ed professors?
  - a. Do you have any other examples?
  - b. What were some things that so-and-so did that made you feel comfortable in math/helped you to understand? (Can you give me another example?)
  - c. What were some things that so-and-so did that made you feel especially anxious? (Can you give me another example?)

[covert categories: math anxiety in pre-service teachers, effect of formal teacher training on math anxiety, avoidance of math]

## TOPIC DOMAIN 4: MATH ANXIETY IN FUTURE TEACHING

1. Describe your future classroom (if applicable).
2. When you picture yourself teaching math, what does it look like?
  - a. What values do you want to instill in your students? (how does that apply to math?)
  - b. What attitudes would you like to promote? (how does that apply to math?)
3. Is there anything you are nervous to teach (subject, specific topics, etc.)?
4. What are you most excited to teach?
5. How do you believe your math anxiety might impact your teaching?
  - a. What do you think you can do to help prevent that from happening?
6. What will you do if you see math anxiety in one of your students?
7. What do you wish your teachers had done to help you with your math anxiety?

[covert category: anxiety about teaching math, comfort level with teaching, relation of math anxiety and general teaching anxiety, desire to prevent math anxiety in future students]

## TOPIC DOMAIN 5: SUMMING UP

8. Is there anything I didn't ask you about that you wish I had?
9. Is there anything else you would like me to know?
10. Anything else?

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## Appendix C

Caroline: Yeah for a little bit I would always go into class and be nervous if she were to call on me or to have to work out a problem on the board. Even though I could do it on paper, I would just get nervous in front of people that I would do it wrong. I always liked numbers and that kind of thing, but I guess [I] just had anxiety and [it led me to] maybe not do as well.

Beth: In high school, at the beginning of the school year, we had mastery tests. I don't know what we had to do it for, but it was just to make sure we understood. We had a summer packet that we did, and then in the beginning of the year we all did mastery tests and you had to get an 85 or above. You had to keep taking it and keep taking it and keep taking it until you passed it. That wasn't fun. You had to go take it, and I feel like everyone knew if you hadn't passed it yet. So, you just had to keep taking it.... One year I think it took me like seven times. So it sucked.

Abigail: Times tables. I did terrible on those. I'd go home and I'd have to practice with my mom and dad, and my little sister would be saying the answers to the flash card things. [My mom] would be like "5 times 2" and my sister, who's two years younger, knew the answer and I'd be like "wait I know that one!" It always took me a second longer than she did.

LLC: Timed/high-pressure math assignments leave lasting bad memories.

HLC: Repeated embarrassment with respect the mathematics leads to avoidance of math-related activities. Over time, this can develop into math anxiety if left alone to fester in students.