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Opportunities to Decrease Elementary Prospective Teachers' Mathematics Anxiety

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Abstract: There is a large body of research that documents mathematics anxiety among elementary prospective teachers (PTs) (e.g., Dutton, 1951; Gresham, 2007; Sloan, 2010). Anxiety about mathematics leaves many PTs with the belief that they are not good at doing mathematics, a fear of doing mathematics, and the response that they do not want to talk about or display this fear to others. This disposition is dangerous for PTs because it perpetuates a cycle of mathematics anxiety with their future students. The goal of this article is to encourage the use of research findings when mathematics teacher educators (MTEs) are working with PTs as a way to decrease PTs' mathematics anxiety levels prior to their entry into the teaching profession. Starting with a summary of research findings about the causes of PTs' mathematics anxiety, this article then presents eight research-based recommendations that MTEs can use to help reduce PTs' mathematics anxiety levels while teaching a mathematics content course designed for elementary PTs. It is important for MTEs to be aware of the prevalence of mathematics anxiety among their PTs, to know where that mathematics anxiety originates so they can avoid intensifying the anxiety, and to utilize research-based strategies for reducing the anxiety. This article presents research on PTs' mathematics anxiety in a way that is easily accessible for MTEs.

Keywords: mathematics anxiety, teacher education, elementary grades.

Introduction

A plethora of research documents mathematics anxiety among elementary prospective teachers (PTs), which are those PTs studying to obtain certification to teach students of ages 5–13 (e.g., Dutton, 1951; Gresham, 2007; Sloan, 2010). Mathematics anxiety is defined as “a general fear of contact with mathematics, including classes, homework, and tests” (Hembree, 1990, p. 45). Anxiety about mathematics leaves many PTs with the belief that they are not good at doing mathematics, with a fear of doing mathematics, and with the response that they do not want to talk about or display this fear to others. The concept includes both negative emotions

regarding mathematics content and negative perceptions about how one will perform in mathematics courses (Wigfield & Meece, 1988), and leads to general avoidance of mathematics when possible (Ashcraft & Krause, 2007). In addition, PTs with mathematics anxiety tend to underperform on assessments (Ashcraft & Moore, 2009), which feeds into their perceptions and fears regarding their mathematical abilities and perpetuates a cycle of mathematics anxiety (Hembree, 1990).

While initial research on mathematics anxiety focused on students of mathematics at multiple grade levels from elementary school through undergraduate education (e.g., Dutton, 1951; Hembree, 1990; Wigfield & Meece, 1988), the concept has been expanded to focus on mathematics anxiety among PTs focused on students of age 5–14 (e.g., Kelly & Tomhave, 1985; Uusimaki & Nason, 2004) and classroom elementary teachers who teach students of age 5–14 (e.g., Beilock, Gunderson, Ramirez, & Levine, 2010). Findings from such studies reveal a prevalence of mathematics anxiety among PTs (e.g., Gresham, 2007; Sloan, 2010) that stays with them through their classroom teaching experience (Gresham, 2018). Researchers find that higher mathematics anxiety levels correlate with lower confidence for teaching mathematics and science (Bursal & Paznokas, 2006), and that mathematics anxiety can influence PTs' expectations of their future students (Mizala, Martinez, & Martinez, 2015). These findings underscore the importance of acknowledging the significance of mathematics anxiety when working with PTs and the need for mathematics teacher educators (MTEs) to implement strategies to decrease their PTs' levels of mathematics anxiety before PTs enter the classroom as classroom teachers. This article will detail the prevalence of PTs' mathematics anxiety, and describe eight research-based suggestions that MTEs can use to decrease mathematics anxiety with PTs in mathematics content courses.

Mathematics Anxiety Among Prospective Teachers

One of the problematic features of mathematics anxiety is that a person who has it has a potentially false self-perception of their understanding of mathematics (e.g., Ashcraft & Kirk, 2001; Beilock & Maloney, 2015; Hembree, 1990). Students as young as first grade have shown evidence of having mathematics anxiety, instances of which continue to increase through ninth grade, and persist into adulthood (Beilock & Maloney, 2015). We know that mathematics anxiety is not related to mathematical ability (Hembree, 1990; Mizala et al., 2015). The falseness that originates from mathematics anxiety can play havoc on one's mindset for learning, and therefore one's ability to succeed in future careers. For PTs, mathematics anxiety is especially problematic because of its potential impact on their ability to learn mathematics for teaching and its potential impact on how they teach mathematics to their students. This section will describe what we know about the prevalence and persistence of mathematics anxiety among the PT population, including what research has shown to be factors in creating and fostering mathematics anxiety.

The prevalence and high levels of mathematics anxiety among the PT population has been well-documented for many years (e.g., Dutton, 1951; Hembree, 1990; Kelly & Tomhave, 1985; Wilson, 2015). In particular, many studies have shown how mathematics anxiety afflicts females at a disproportionate rate (Beilock et al., 2010; Hembree, 1990; Kelly & Tomhave, 1985). Due to the high numbers of female classroom teachers at the elementary grade levels, research has especially focused on how females are more prone to have mathematics anxiety than males (e.g., Hembree, 1990; Kelly & Tomhave, 1985). For instance, Beilock et al. (2010) found that female students of multiple grade levels show higher levels of mathematics anxiety and lower levels of mathematics achievement when they are taught by highly anxious female

classroom teachers. Further, they found that the female classroom teachers promoted negative stereotypes about female students' academic performance, saying that "the higher a teacher's math anxiety, the more likely girls' ability beliefs were to fall along traditional gender lines" by the end of the school year (Beilock et al., 2010, p. 1861).

A lack of self-confidence and lack of self-efficacy both correspond with high mathematics anxiety (e.g., Beilock & Maloney, 2015; Finlayson, 2014; Gonzalez-DeHass, Furner, Vasquez-Colina, & Morris, 2017; Mizala et al., 2015; Swars, Daane, & Giesen, 2006). A lack of self-confidence affects both PTs' confidence towards doing mathematics (e.g., Harper & Daane, 1998) and towards teaching mathematics (e.g., Sloan, 2010). Bursal and Paznokas (2006) report that "nearly half of the preservice teachers having higher math anxieties than their colleagues believe that they will not be able to teach math effectively" (p. 177). They also found that mathematics anxiety affects PTs' self-confidence with teaching science, which means the problems stemming from mathematics anxiety will affect more than just one academic subject.

Along with their self-confidence about teaching, mathematics anxiety has also been shown to affect PTs' beliefs about their future students. Higher mathematics anxiety scores of classroom teachers correlate with lower expectations for their students' future mathematics performance, and also with the use of pedagogical strategies typically reserved for special education students (Mizala et al., 2015). Regardless of their mathematics anxiety level, PTs tend to create lessons that are instructor-focused, describing the classroom teacher's role as demonstrative while students listen (Cady & Rearden, 2007). It has also been shown that PTs expect males to do better than females in future mathematics courses (Mizala et al., 2015).

Research findings also help us understand how mathematics anxiety is triggered and from where it originates. By far, the most prevalent source for mathematics anxiety is previous formal

education experiences (e.g., Harper & Daane, 1999; Jackson & Leffingwell, 1999). PTs self-report that the most common origin of their mathematics anxiety is from experiences with their elementary (e.g., Trujillo & Hadfield, 1999; Uusimaki & Nason, 2004) or secondary (Cady & Rearden, 2007) mathematics classes and classroom teachers. Middle school experiences were found to be mixed in terms of their influence on PTs' mathematics anxiety (Cady & Rearden, 2007). While the self-reported experiences that led to mathematics anxiety were negative, PTs also reported that positive elementary school experiences were correlated to positive beliefs about mathematics (Cady & Rearden, 2007) and confidence in teaching mathematics (Brady & Bowd, 2005).

Due to the prevalence of blame placed on formal school experiences for their role in creating and fostering mathematics anxiety among PTs, researchers have completed numerous studies to explore and explain the factors involved in generating mathematics anxiety. Societal norms around classroom teachers and teaching are some of the most common reasons for high levels of mathematics anxiety among PTs (Beilock & Maloney, 2015), including: teaching styles, classroom teachers' beliefs about mathematics, ineffective learning practices, and non-engagement of students. Examples of teaching styles that promoted anxiety included: classroom teachers who focused heavily on quickly finishing a large amount of content (Cornell, 1999; Finlayson, 2014), emphasized procedural skills (Cornell, 1999; Finlayson, 2014) or right answers (Harper & Daane, 1998; Kelly & Tomhave, 1985), did not explain ideas, procedures, or vocabulary completely (Cornell, 1999; Sloan, 2010), placed the authority related to content with the classroom teacher (Finlayson, 2014), were dismissive when students did not measure up to their assumptions of student knowledge (Cornell, 1999), and did not make connections between the mathematics content and real-world issues (Cornell, 1999).

Societal norms that influence mathematics anxiety among PTs were also linked to classroom teachers' beliefs about their students and their students' mathematical abilities. PTs linked their mathematics anxiety to instances where classroom teachers said that mathematics was easy, but they found themselves to be struggling, or when it was evident that the classroom teacher did not like doing or teaching mathematics (Finlayson, 2014). According to multiple research studies, classroom teachers often projected negative attitudes about mathematics (e.g., Kelly & Tomhave, 1985; Sloan, 2010), which led to feelings of mathematics anxiety in their students. Teaching practices such as calling out students to answer questions in front of their peers (Finlayson, 2014; Kelly & Tomhave, 1985), placing time constraints on assessments (Finlayson, 2014; Harper & Daane, 1998), asking students to compete with each other (Finlayson, 2014), or only accepting traditional ways of problem solving (Kelly & Tomhave, 1985) were also found to increase mathematics anxiety levels within the PT population. PTs' decisions regarding their learning were also found to influence their own mathematics anxiety levels. For instance, PTs who did not study and were not prepared to take exams reported feeling anxious (Finlayson, 2014). Sloan (2010) found that PTs' negative attitudes about mathematics, such as not liking mathematics class, also promoted mathematics anxiety. Additionally, Cornell (1999) reported that PTs who leaned too heavily on memorization rather than working to understand mathematical concepts experienced increased mathematics anxiety.

Beyond the way that societal norms of teaching and classroom teachers influence and promote mathematics anxiety among PTs, research has also demonstrated a link between other experiences and PTs' levels of mathematics anxiety. These experiences include: interactions with parents who felt they were never good at mathematics and believed that their children would not be either (Beilock & Maloney, 2015; Finlayson, 2014; Sloan, 2010; Trujillo & Hadfield, 1999), a

fear of failure when doing mathematics (Finlayson, 2014; Gonzalez-DeHass et al., 2017; Harper & Daane, 1998; Sloan, 2010), anxiety about mathematics testing (Sloan, 2010; Uusimaki & Nason, 2004; Wilson, 2015), and engaging in word problems and problem solving (Harper & Daane, 1998). In addition, research studies such as one by Stoehr (2017) demonstrate the potential for additional experiences that have not yet been identified to influence the anxiety that PTs feel around mathematics.

Given the prevalence of mathematics anxiety among PTs, it is crucial that MTEs are aware of the causes of that anxiety so that they can avoid perpetuating the problem during mathematics content courses specifically designed for PTs. Furthermore, it is also imperative that MTEs consider ways in which to reduce mathematics anxiety before PTs become classroom teachers so that the cycle can be broken. While there is not a clear roadmap of how to do this, there are a myriad of research studies that present promising suggestions based on their findings. This article will present eight research-based recommendations that MTEs can use to address their PTs' mathematics anxiety with the goal of reducing anxiety levels during a mathematics content course designed for elementary PTs.

Research-Based Recommendations for Addressing PTs' Mathematics Anxiety

Table 1 presents several research-based recommendations for reducing PTs' mathematics anxiety. It is important to note that multiple research findings indicate the usefulness of methods courses in reducing PTs' mathematics anxiety (e.g., Gresham, 2018). While acknowledging the importance of longevity in combating PTs' mathematics anxiety, MTEs should consider ways in which they can promote cohesiveness across the multiple dimensions (i.e. content and methods courses) of teacher preparation programs. While research on mathematics anxiety has focused on exploring the ways in which mathematics methods courses can be useful in reducing PTs' levels

of anxiety (e.g., Battista, 1986; Beilock & Willingham, 2014; Gresham, 2018; Sloan, 2010; Tooke & Lindstrom, 1998; Vinson, 2001), this article extracts recommendations from such studies that can be utilized in mathematics content courses for PTs. These recommendations are described in detail below.

Table 1

Research-Based Strategies for MTEs Working to Reduce PTs' Mathematics Anxiety

Research-based strategies to reduce mathematics anxiety when working with PTs
<ol style="list-style-type: none"> 1. Engage PTs in a community of learning, where they work together and support each other. 2. Create a supportive atmosphere with individualized feedback. 3. Directly address PTs' mathematics anxiety and work with them to combat it. 4. Engage PTs in writing assignments about mathematics and mathematics anxiety. 5. Change the framing and language used during mathematics courses. 6. Situate the mathematics in real-life contexts. 7. Use manipulatives, but be sensitive to PTs' learning curve with new materials. 8. Discuss prevalence of mathematics anxiety among K–12 students and ways to reduce it.

The first two recommendations are about how the community and atmosphere created in a course can help reduce PTs' mathematics anxiety. Multiple research findings indicate that forming a close community of learners within a classroom where PTs learn to support and rely on each other can be an effective way to decrease mathematics anxiety levels (Gonzalez-DeHass et al., 2017; Gresham, 2007; Harper & Daane, 1998; Uusimaki & Nason, 2004). For instance, multiple studies recommend increasing the amount of time PTs work together in groups (Dutton, 1951; Gresham, 2007; Harper & Daane, 1998; Uusimaki & Nason, 2004). A few research-based suggestions for engaging PTs in a community of learning include encouraging small group discussions that are led by PTs (Dutton, 1951), emphasizing and encouraging PTs working together both in and out of class (Harper & Daane, 1998), and providing time for PTs to communicate with each other about mathematics in a supportive environment (Uusimaki &

Nason, 2004). Specifically, Gonzalez-DeHass and colleagues (2017) recommend incorporating mathematical tasks into lessons that require PTs to engage together as they work towards a solution. One way this can be done is to suggest each group member embody a specific role, such as a summarizer, a time organizer, or a recorder (Johnson & Johnson, 1999) in the discussion. Feldman, Wickstrom, Hajra, and Gupta (2020) recommend using tasks that require PTs to engage in uncertainty as they work through their mathematical thinking. Another way to promote supportive and inclusive conversation is to use research-based tools for facilitating meaningful mathematical discourse, such as asking PTs to share counter examples with the whole class or for MTEs to listen to small group interactions to identify areas of confusion that may need to be brought to the whole group (Lister, MacDonald, & Shumway, 2020). For additional details and suggestions for orchestrating and encouraging successful group work, refer to Horn (2012) or Johnson and Johnson (1999). Overall, the goal in creating a community is to help reduce the mathematics anxiety that PTs often feel when they have to share their mathematical knowledge. Providing opportunities for PTs to share their mathematical thoughts with small groups can help promote a more inclusive, safe, and collaborative community as PTs learn to rely on and be comfortable with each other.

Creating a supportive atmosphere with individualized feedback relies more on the actions of the MTE than creating a supportive community does. Researchers found it advantageous towards reducing the mathematics anxiety levels of PTs when MTEs had inviting dispositions and provided feedback in an individualized manner (e.g., Gonzalez-DeHass, 2017; Gresham, 2007). For instance, Gresham (2007) found that PTs attributed a decrease in their mathematics anxiety to their MTE's enthusiasm towards the course content. This enthusiasm could manifest through MTEs introducing a topic by providing reasons why they get excited about it, or

explaining how a particular topic might be difficult but that it is exciting once PTs better understand it through their course activities. Sloan (2010) found that PTs attributed their own mathematics anxiety towards their MTEs' "harsh, unapproachable, and intimidating" character (p. 254). While it is difficult to separate truth and perception, it is important to note that PTs are especially susceptible to this interpretation of their MTEs' dispositions. Considerations such as carefully reflecting on language in emails, showing concern towards various circumstances PTs face in their lives while enrolled in courses, and being explicit about accommodations that fit within an MTE's schedule may help to create a supportive and inclusive environment and helps to demonstrate MTEs' respect towards their PTs.

Additionally, creating a supportive environment includes providing individualized and thoughtful feedback to PTs (e.g. Gonzalez-DeHass et al., 2017). Part of this recommendation is to communicate with PTs that mistakes are an integral part of any learning (Finlayson, 2014) and treating mistakes as such. One suggestion of how to do this is to discuss mistakes in a way that provides students opportunities to learn and does not put down the student who made the mistake. Gonzalez-DeHass and colleagues (2017) recommend providing feedback on evaluations that focus on an individual's goals and progress rather than comparing individual assessment results to the results of the whole class. An example of this is to not advertise a class average after an exam, but rather to encourage PTs to reflect on their own growth with the material. The overall intent is to provide a supportive environment that promotes collaboration among the PTs and for the MTE to create an inviting atmosphere.

The next two recommendations focus highlighting and discussing PTs' own mathematics anxiety in ways that may help reduce it. Multiple recommendations include identifying mathematics anxiety levels among PTs (e.g., Harper & Daane, 1998; Johnson & VanderSandt,

2011; Kelly & Tomhave, 1985), potentially using the commonly accepted Mathematics Anxiety Rating Scale (Suinn & Winston, 2003). The 30-question survey (Suinn & Winston, 2003, p.169) asks PTs to rate their level of anxiety with respect to a variety of experiences with mathematics. MTEs could ask their PTs to take the survey on a platform such as Google Forms or Qualtrics, and then compile the results for the group as a whole as well as for individual PTs. Harper and Daane (1998) report that helping PTs to identify and reflect on their previous experiences with mathematics and their mathematics anxiety levels may help them to create less anxious mathematics classrooms when they teach in the future. One way to do this is to give an overview of results from a mathematics anxiety survey after PTs have had a chance to take it at the start of a course. This may help normalize PTs' anxiety and make them feel more secure in recognizing it and then working to reduce it throughout the semester.

Beyond the survey results, MTEs can also engage PTs in short conversations about how they are feeling about particular topics, or the class in general, during different weeks throughout the semester. During these conversations, MTEs could ask PTs to “trace the origins of their fears” (Kelly & Tomhave, 1985, p. 52), and make connections between their current mathematics anxiety and their past mathematics experiences so as to better understand and confront their anxiety. MTEs can also present PT-identified strategies that Finlayson (2014) reports as being successful tools for PTs to alleviate their own mathematics anxiety levels. These include: staying organized and studying so as not to fall behind, making connections to previous understandings, focusing and building on any mathematical successes, practice self-talk to calm themselves down, and asking for help when needed (Finlayson, 2014). Using the Mathematics Anxiety Rating Scale (Suinn & Winston, 2003) in combination with group discussions and

suggesting PT-driven strategies, MTEs can bring PTs' mathematics anxiety into the discussion and help PTs address their own mathematics anxiety during the course.

Another specific way of engaging PTs in confronting their own mathematics anxiety is to ask them to write about both their anxiety and about mathematics in general (e.g., Gresham, 2007; Harper & Daane, 1998; Wilson, 2015). In one of the first research studies on mathematics anxiety, Dutton (1951) noted that when PTs recorded their thoughts about mathematics it helped them overcome their own anxieties as well as informed the MTE about what PTs were feeling with regards to the mathematics. This is supported by more recent research which suggests that writing about mathematics and mathematics anxiety can help reduce anxiety levels among PTs (Harper and Daane, 1998; Gresham, 2007). Suggested prompts include: asking PTs to write about “a critical incident (positive or negative) from their own school mathematics education that impacted ton their image of themselves as learning of mathematics” (Wilson, 2015, p. 646), or requiring PTs to “keep journal logs of their thoughts and processes” (Gresham, 2007, p. 185) throughout the course. Gonzalez-DeHass and colleagues (2017) suggest using journal writing as an alternative assessment to evaluate PTs mathematical knowledge, and Liu (2008) noted that PTs participation in online discussion boards, guided with the seven prompts stated in Table 2, helped to reduce their anxiety. In addition to formal assessments, MTEs could consider asking PTs to engage in an “expressive writing exercise” where they write “openly for 5 to 10 minutes about their feelings regarding [an] upcoming math test” (Beilock & Maloney, 2015). The research strongly suggests that asking PTs to write about their mathematical understandings or their mathematics anxiety will help reduce their mathematics anxiety levels, and MTEs should find places to include such assignments in their courses.

Table 2

Liu's (2008) Online Writing Topics for PTs

Liu's (2008) online writing topics for PTs
<ol style="list-style-type: none"> 1. Why are some of us anxious about teaching math? 2. Can anxiety towards teaching mathematics be overcome? 3. Is mathematics more difficult than the other subjects? 4. Which should be more emphasized: Understanding or memorizing mathematics facts? 5. Is gender a factor? 6. Ways to overcome anxiety towards mathematics. 7. How not to instill mathematics anxiety in your own students.

Recommendations 5, 6 and 7 are suggestions focused on the way the content is explored in mathematics content courses, beyond writing assignments. The first is to change the language of course content towards a focus on how students learn mathematics rather than on the mathematics itself (Dutton, 1951; Tooke & Lindstrom, 1998). Cady and Rearden (2007) found that using terms such as “investigating”, “experimenting”, “discovery”, or “inquiry” rather than “problem” or “problem solving” helped to change the connotation for PTs and improve their experiences with mathematics. To consistently use this recommendation, an MTE might consider reviewing daily lessons to replace the terms Cady and Rearden (2007) suggest avoiding. MTEs might also consider including artifacts of children’s thinking as a way of engaging PTs in mathematics focused on how students learn (Max & Welder, 2020). Additionally, multiple findings recommend situating the mathematical content in real-life contexts (i.e., Gonzalez-DeHass et al., 2017; Gresham, 2007). Gonzalez-DeHass and colleagues (2017) suggest situating mathematical tasks in real-world challenges in which PTs might engage. For instance, a problem on multiplying fractions might ask PTs about a situation where $\frac{1}{3}$ of their students went to the library and $\frac{1}{2}$ of those students had overdue library books. Textbooks designed for PTs frequently include multiple examples of such contexts (i.e., Beckmann, 2018). MTEs can also

come up with relevant contexts to modify problems by talking with their PTs about teaching and learning tasks in which they are engaged, such as tutoring or field experiences related to other education courses. Problem contexts to which the PTs relate make the activities more concrete and meaningful to PTs, which can help them apply their learning to realistic situations (Uusimaki & Nason, 2004) and reduce their mathematics anxiety (Gresham, 2007). Bernander, Szydik, and Seaman (2020) provide examples of how to situate the mathematics as concrete and meaningful to PTs through illustrations of a variety of lessons. Meaningful contexts are not easily incorporated into all lessons, but the more PTs see how the mathematics they are learning is useful in the real world, the more it can help to reduce their anxiety towards the content.

Another way to make the mathematics seem more tangible to PTs is to provide manipulatives during the course. Multiple studies have found that the use of manipulatives, such as interlocking cubes, pentaminoes, tangrams, geoboards, pattern blocks, and others, contributed to the reduction of mathematics anxiety among PTs (e.g., Gresham, 2007; Harper & Daane, 1998; Sloan, 2010; Vinson, 2001). Sloan (2010) noted that manipulatives helped foster conceptual understanding, enhanced PTs' self-confidence, and promoted positive attitudes towards mathematics. The use of manipulatives also improved PTs' confidence in teaching mathematics because they felt like they had resources to make the content more enjoyable for their future students (Sloan, 2010). However, researchers also noted that while manipulatives helped decrease the majority of PTs' mathematics anxiety, they were also the cause of some PTs' increased mathematics anxiety because the materials were not familiar to them (Gresham, 2007; Sloan, 2010; Vinson, 2001). MTEs should be aware of this caveat and provide time for PTs to learn how to use manipulatives effectively during lessons. Refer to Kuennen and Beam (2020) as

well as Appova and Taylor (2020) for specific examples and illustrations of how to use manipulatives successfully with PTs.

Recommendation 8 might be used more prevalently in methods courses, but can still be incorporated into a content course. Multiple studies suggest educating PTs on mathematics anxiety, including the known causes of mathematics anxiety in students (Sloan, 2010), and ways in which they can reduce it with their future students (Beilock & Maloney, 2015). More detailed conversations about elementary students' mathematics anxiety should be a topic of conversation during methods courses; however, MTEs of content courses can increase their own awareness of the causes of mathematics anxiety and include pieces of information when teaching their course. For example, it is widely known that exposure to negative attitudes about mathematics can promote mathematics anxiety in students as young as elementary school age (Beilock & Maloney, 2015). MTEs can share this information with their PTs and introduce their content course as one way to help change negative dispositions. MTEs can also be explicit about the actions they are taking to help reduce PTs' mathematics anxiety, such as the recommendations in

Table 1, and occasionally suggest that PTs can use similar strategies when they are working with their own students. Lastly, MTEs can communicate with their counter parts who teach methods courses to suggest that deeper conversations around mathematics anxiety, including causes and ways to reduce it, are happening in methods courses.

Overall, it is important that MTEs work with PTs to reduce levels of mathematics anxiety as much as possible during teacher preparation programs. Content specific courses have the potential to increase PTs' levels of mathematics anxiety by not considering the eight recommendations put forth in this article. If MTEs can work to help reduce the mathematics anxiety of PTs before they get to methods courses, then methods courses have the potential of

making an even greater difference in PTs' experiences with mathematics prior to their entry into classroom teaching.

Conclusion

The high levels of mathematics anxiety found among PTs make the job of MTEs difficult because we are competing with many PTs' desires to avoid mathematics as much as possible. The researched-based suggestions described in this article provide concrete actions that can be used to help reduce PTs' mathematics anxiety. From the start of a new semester, MTEs should work to create a collaborative and supportive environment for their PTs by encouraging reflective group work and by being compassionate with their PTs. Research on mathematics anxiety indicates the likelihood that a majority of PTs suffer from some degree of mathematics anxiety (e.g., Gresham, 2007; Sloan, 2010), which would imply that they would want to shy away from any interactions where they would have to talk about their mathematical understandings, such as group conversations with their peers (Hembree, 1990). However, these research-based recommendations suggest that engaging PTs in conversations and writing about mathematics and mathematics anxiety may actually help to reduce their anxiety. Additionally, MTEs can work to make the mathematics content more accessible to PTs by using particular language that is shown to have a positive connotation, situating the mathematics content in applicable scenarios, and providing a structured way for PTs to use manipulatives when they are engaging in the content. Research-based recommendations also include discussing the prevalence of mathematics anxiety among elementary students and talking with PTs about some of the remedies for anxiety that they can use with future students. The research is clear that methods courses are an effective way to reduce PTs' mathematics anxiety levels, and instructors

of content courses can use the eight research-based recommendations presented in this article to support those efforts prior to PTs' enrollment in methods courses.

References

- Appova, A. & Taylor, C. E. (2020). Providing opportunities to develop prospective teachers' pedagogical content knowledge. In A. Appova, R. M. Welder, and Z. Feldman, (Eds.), *Supporting Mathematics Teacher Educators' Knowledge and Practices for Teaching Content to Prospective (Grades K-8) Teachers. Special Issue: The Mathematics Enthusiast*, ISSN 1551-3440, vol. 17, nos. 2 & 3, pp. 673-724. ScholarWorks: University of Montana. Retrieve (open access) from: <https://scholarworks.umt.edu/tme>
- Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General*, 130(2), 224–237. doi: 10.1037//0096-3445.130.2.224
- Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review*, 14(2), 243–248. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/204829353?accountid=12598>
- Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and affective drop in performance. *Journal of Psychoeducational Assessment*, 27(3), 197–205. doi: 10.1177/0734282908330580
- Battista, M. T. (1986). The relationship of mathematics anxiety and mathematical knowledge to the learning of mathematical pedagogy by preservice elementary teachers. *School Science and Mathematics*, 86(1), 10–19. Retrieved from

<http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/63328195?accountid=12598>

Beckmann, S. (2018). *Mathematics for elementary teachers with activities*. (5th ed.). New York, NY: Pearson.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(5), 1860–1863. doi: 10.1073/pnas.0910967107

Beilock, S. L., & Maloney, E. A. (2015). Math anxiety: A factor in math achievement not to be ignored. *Policy Insights from the Behavioral and Brain Sciences*, *2*(1), 4–12. doi: 10.1177/2372732215601438

Beilock, S. L., & Willingham, D. T. (2014). Math anxiety: Can teachers help students reduce it? *American Educator*, *38*(2), 28–43. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/1651850849?accountid=12598>

Bernander, S., Szyklik, J. E., & Seaman, C. E. (2020). Fostering and modeling the common core standards for mathematical practice in content courses for prospective elementary teachers. In A. Appova, R. M. Welder, and Z. Feldman, (Eds.), *Supporting Mathematics Teacher Educators' Knowledge and Practices for Teaching Content to Prospective (Grades K-8) Teachers. Special Issue: The Mathematics Enthusiast*, ISSN 1551-3440, vol. 17, nos. 2 & 3, pp. 907-937. ScholarWorks: University of Montana. Retrieve (open access) from: <https://scholarworks.umt.edu/tme>

- Brady, P., & Bowd, A. (2005). Mathematics anxiety, prior experience and confidence to teach mathematics among pre-service education students. *Teachers and teaching*, 11(1) 37–46. doi: 10.1080/1354060042000337084
- Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics*, 106(4), 173–180. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/195204007?accountid=12598>
- Cady, R. A., & Rearden, K. (2007). Pre-service teachers' beliefs about knowledge, mathematics, and science. *School Science and Mathematics*, 107(6), 237–245. doi: 10.1111/j.1949-8594.2007.tb18285.x
- Cornell, C. (1999). I hate math! I couldn't learn it and I can't teach it! *Childhood Education*, 75(4), 225–230. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/210387946?accountid=12598>
- Dutton, W. H. (1951). Attitudes of prospective teachers toward arithmetic. *The Elementary School Journal*, 52(2), 84–90. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/1290211561?accountid=12598>
- Feldman, Z., Wickstrom, M., Ghosh Hajra, S., & Gupta, D. (2020). The role of uncertainty in mathematical tasks for prospective elementary teachers. In A. Appova, R. M. Welder, and Z. Feldman, (Eds.), *Supporting Mathematics Teacher Educators' Knowledge and Practices for Teaching Content to Prospective (Grades K-8) Teachers. Special Issue: The*

Mathematics Enthusiast, ISSN 1551-3440, vol. 17, nos. 2 & 3, pp. 641-672.

ScholarWorks: University of Montana. Retrieve (open access) from:

<https://scholarworks.umt.edu/tme>

Finlayson, M. (2014). Addressing math anxiety in the classroom. *Improving Schools*, 17, 99–115. doi: 10.1177/1365480214521457

Gonzalez-DeHass, A. R., Furner, J. M., Vasquez-Colina, M. D., & Morris, J. D. (2017). Pre-service elementary teachers' achievement goals and their relationship to math anxiety. *Learning and Individual Differences*, 60, 40–45. doi: 10.1016/j.lindif.2017.10.002

Gresham, G. (2007). A study of mathematics anxiety in pre-service teachers. *Early Childhood Education Journal*, 35(2), 181–188. doi: 10.1007/s10643-007-0174-7

Gresham, G. (2018). Preservice to inservice: Does mathematics anxiety change with teaching experience? *Journal of Teacher Education*, 69(1), 90–107. doi: 10.1177/0022487117702580

Harper, N. W., & Daane, C. J. (1998). Causes and reduction of math anxiety in preservice elementary teachers. *Actions in Teacher Education*, 19(4), 29–38. doi: 10.1080/01626620.1998.10462889

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, 21(1), 33–46. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/63074737?accountid=12598>

Horn, I. S. (2012). *Strength in numbers: Collaborative learning in secondary mathematics*. Reston, VA: National Council of Teachers of Mathematics.

- Jackson, C. D., & Leffingwell, R. J. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *The Mathematics Teacher*, 92(7), 583–586. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/62391420?accountid=12598>
- Johnson, D. W., & Johnson, R. T. (1999). Making cooperative learning work. *Theory into Practice*, 38(2), pp. 67–73. doi: 10.1080/00405849909543834
- Johnson, B., & S. vanderSandt, S. (2011). “Math makes me sweat”: The impact of pre-service courses on mathematics anxiety. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, 5, 1–8. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/1018481027?accountid=12598>
- Kelly, W. P., & Tomhave, W. K. (1985). A study of math anxiety/math avoidance in preservice elementary teachers. *The Arithmetic Teacher*, 32(5), 51–53. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/63387144?accountid=12598>
- Kuennen, E. W. & Beam, J. E. (2020). Teaching the mathematics that teachers need to know: Classroom ideas for supporting prospective elementary teachers’ development of mathematical knowledge for teaching. In A. Appova, R. M. Welder, and Z. Feldman, (Eds.), *Supporting Mathematics Teacher Educators’ Knowledge and Practices for Teaching Content to Prospective (Grades K-8) Teachers. Special Issue: The Mathematics Enthusiast*, ISSN 1551-3440, vol. 17, nos. 2 & 3, pp. 771-805. ScholarWorks: University of Montana. Retrieve (open access) from: <https://scholarworks.umt.edu/tme>

- Litster, K., MacDonald, B., & Shumway, J. F. (2020). Experiencing active mathematics learning: Meeting the expectations for teaching and learning in mathematics classrooms. In A. Appova, R. M. Welder, and Z. Feldman, (Eds.), *Supporting Mathematics Teacher Educators' Knowledge and Practices for Teaching Content to Prospective (Grades K-8) Teachers. Special Issue: The Mathematics Enthusiast*, ISSN 1551-3440, vol. 17, nos. 2 & 3, pp. 615-640. ScholarWorks: University of Montana. Retrieve (open access) from: <https://scholarworks.umt.edu/tme>
- Liu, F. (2008). Impact of online discussion on elementary teacher candidates' anxiety towards teaching mathematics. *Education*, 128(4), 614–630. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/61952744?accountid=12598>
- Max, B. & Welder, R. M. (2020). Mathematics teacher educators' addressing the common core standards for mathematical practice in content courses for prospective elementary teachers: A focus on critiquing the reasoning of others. In A. Appova, R. M. Welder, and Z. Feldman, (Eds.), *Supporting Mathematics Teacher Educators' Knowledge and Practices for Teaching Content to Prospective (Grades K-8) Teachers. Special Issue: The Mathematics Enthusiast*, ISSN 1551-3440, vol. 17, nos. 2 & 3, pp. 843-881. ScholarWorks: University of Montana. Retrieve (open access) from: <https://scholarworks.umt.edu/tme>
- Mizala, A., Martinez, F., & Martinez, S. (2015). Pre-service elementary school teachers' expectations about student performance: How their beliefs are affected by their mathematics anxiety and student's gender. *Teaching and Teacher Education*, 50. 70–78.

- National Council of Teachers of Mathematics (NCTM). (2014). *Principles to actions: Ensuring mathematical success for all*. Reston, VA: NCTM. doi: 10.1016/j.tate.2015.04.006
- Sloan, T. R. (2010). A quantitative and qualitative study of math anxiety among preservice teachers. *The Educational Forum*, 74(3), 242–256. doi: 10.1080/00131725.2010.483909
- Stoehr, K. J. (2017). Building the wall brick by brick: one prospective teacher's experiences with mathematics anxiety. *Journal of Mathematics Teacher Education*, 20(2), 119-139. doi: 10.1007/s10857-015-9322-y
- Suinn, R. F. & Winston, E. H. (2003). The mathematics anxiety rating scale, a brief version: Psychometric data. *Psychological Reports*, 92. 167–173.
- Swars, S. L., Daane, C. J., & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? *School Science and Mathematics*, 106(7), 306–315. doi: 10.1111/j.1949-8594.2006.tb17921.x
- Tooke, D. J., & Lindstrom, L. C. (1998). Effectiveness of a mathematics methods course in reducing math anxiety of preservice elementary teachers. *School Science and Mathematics*, 98(3), 136–139. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/195202716?accountid=12598>
- Trujillo, K. M., & Hadfield, O. D. (1999). Tracing the roots of mathematics anxiety through in-depth interviews with preservice elementary teachers. *College Student Journal*, 33(2), 219–232. Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/619398888?accountid=12598>

Uusimaki, L., & Nason, R. (2004). Causes underlying pre-service teachers' negative beliefs and anxieties about mathematics. Paper presented at the 28th conference of the International

Group for the Psychology of Mathematics Education, July 14–18, Bergen, Norway.

Retrieved from <http://ezproxy.msu.edu.proxy2.cl.msu.edu/login?url=https://search-proquest-com.proxy2.cl.msu.edu/docview/62070993?accountid=12598>

Vinson, B. M. (2001). A comparison of preservice teachers' mathematics anxiety before and after a methods class emphasizing manipulatives. *Early Childhood Education Journal*, 29(2), 89–94. doi: 10.1023/A:1012568711257

Wigfield, A. & Meece, J. L. (1988). Math anxiety in elementary and secondary students. *Journal of Educational Psychology*, 80(2), 210–216. doi: 10.1037/0022-0663.80.2.210

Wilson, S. (2015). "I was in year 5 and I failed maths": Identifying the range and causes of maths anxiety in first year pre-service teachers. In M. Marshman, V. Geiger, & A. Bennison (Eds.). *Mathematics education in the margins* (Proceedings of the 38th annual conference of the Mathematics Education Research Group of Australasia), pp. 643–650. Sunshine Coast: MERGA.