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Using a Mixed Methods Approach to Study the Relationship Between Mathematics Anxiety, Mathematics Teacher Efficacy, and Mathematics Teaching Anxiety in Preservice Elementary School Teachers in Ontario

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Abstract Preservice elementary school teachers are under ever increasing pressure to deliver quality mathematics instruction to their students. Mathematics anxiety and mathematics teacher efficacy are constructs that are commonly measured in preservice elementary school teachers and are used to help identify future challenges these preservice teachers might have when teaching mathematics. Mathematics teaching anxiety is a relatively new construct measured in preservice elementary school teachers. Mathematics teaching anxiety aims to separate the anxiety experienced when *doing* mathematics from the anxiety experienced when *teaching* mathematics. This study used a modified version of an explanatory sequential mixed methods design to examine the relationship between mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy in preservice elementary school teachers in Ontario. Participants were preservice elementary school teachers across six teacher education programs in Ontario. Questionnaire data was gathered from 185 participants, 16 of whom were also interviewed. Results indicate that mathematics teaching anxiety is significantly correlated to both mathematics teacher efficacy and mathematics anxiety, but there was a lack of correlation between mathematics anxiety and mathematics teacher efficacy. These results indicate that mathematics teaching anxiety does interact with mathematics anxiety; however, mathematics teacher efficacy and the introduction of mathematics teaching anxiety may disrupt the previous belief that mathematics anxiety and mathematics teacher efficacy are negatively correlated. Furthermore, interview and short answer responses showed that preservice elementary school teachers who were mathematically anxious were aware of their anxieties and developed methods of overcoming their feelings while maintaining effective teaching practices.

Résumé Les enseignants en formation initiale font l'objet d'une pression toujours croissante pour fournir à leurs élèves une éducation de qualité en mathématiques. L'appréhension à l'égard des mathématiques et l'efficacité des éducateurs à enseigner cette matière sont des constructions mentales couramment mesurées chez les enseignants en formation initiale destinés au primaire et elles sont utilisées pour aider à déterminer les défis futurs que pourrait rencontrer ce personnel en formation, dans la

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pratique de l'enseignement des mathématiques. L'appréhension reliée à l'enseignement des mathématiques, évaluée chez les enseignants en formation initiale destinés au primaire est une construction relativement nouvelle. Ce type d'appréhension distingue l'angoisse ressentie quand on fait des mathématiques de celle qui se manifeste lorsque l'on enseigne cette matière. Dans cette étude, nous avons utilisé une version modifiée d'une démarche de recherche explicative à méthodes mixtes et séquentielles pour analyser les liens qui ressortent entre l'angoisse à l'égard des mathématiques, l'appréhension reliée à l'enseignement de cette matière et l'efficacité à enseigner les mathématiques chez les éducateurs en formation initiale destinés au primaire en Ontario. Parmi ce groupe, les participants furent recrutés dans six programmes de formation du personnel enseignant en Ontario. La collecte de données par questionnaire a été effectuée auprès de 185 participants et on a aussi interviewé 16 d'entre eux. Les résultats ont révélé une corrélation importante entre l'appréhension reliée à l'enseignement des mathématiques à la fois avec l'efficacité des éducateurs à enseigner cette matière et avec l'angoisse à l'égard des mathématiques alors qu'il n'y avait aucune corrélation entre cette dernière et l'efficacité des éducateurs à enseigner les mathématiques. Ces résultats indiquent que l'appréhension reliée à l'enseignement des mathématiques interagit avec l'angoisse à l'égard de cette matière ainsi qu'avec l'efficacité des éducateurs à l'enseigner, et l'apparition de l'appréhension reliée à l'enseignement des mathématiques peut remettre en cause l'idée reçue que l'angoisse à l'égard des mathématiques et l'efficacité des éducateurs à enseigner cette matière sont en corrélation négative. De plus, l'analyse des réponses recueillies lors des entrevues et de celles à court développement montre que les enseignants en formation initiale destinés au primaire, angoissés à l'égard des mathématiques étaient conscients de leurs appréhensions et ont élaboré des mécanismes pour surmonter leurs impressions tout en maintenant des pratiques d'enseignement efficaces.

Keywords Preservice teacher education · Mathematics teaching anxiety · Mathematics teacher efficacy · Mathematics anxiety

Introduction

The relationship between mathematics anxiety (the feeling of tension or fear when engaging with mathematics) and mathematics teacher efficacy (the belief in one's ability to achieve a desired outcome when teaching mathematics) and their impact on preservice elementary school teachers is a well-researched area of mathematics teacher education (Bursal & Paznokas, 2006; Gresham & Burleigh, 2019; Unlu et al., 2017). Interestingly, there is a lack of research done with preservice elementary school teachers involving mathematics *teaching* anxiety (the feeling of tension or fear when *teaching* mathematics). Mathematics teacher efficacy values the importance of context—contextualizing general self-efficacy, to mathematics self-efficacy, and furthermore to mathematics teacher efficacy—but with mathematics anxiety there is no contextual leap from being a student of mathematics to teaching mathematics.

It is not hard to imagine an individual who enjoys mathematics as a solitary endeavor but struggles to convey their thoughts and strategies to an elementary student. Similarly, it is not inconceivable to envision someone who is a gifted teacher of mathematics, but when asked about their personal relationship with mathematics they think about their struggles with integrals, differentiation, and quadratics (all concepts that are unrelated to teaching mathematics in an elementary school). These examples show a disconnect between an individual's relationship with mathematics as a student and their relationship with mathematics as a teacher. When measuring mathematics anxiety, the individual is placed in the student role of mathematics, not in the teacher role of mathematics. When preservice elementary school teachers' levels of mathematics anxiety are measured and used as a predictor of their ability to teach mathematics, we are overlooking individuals like those described above. This disconnect has been noted in past research. Specifically, Brown et al. (2011) found that "preservice teachers with low or no

mathematics anxiety in their prior experiences can still possess mathematics teaching anxiety when teaching mathematics to students, and vice versa for preservice teachers with high levels of mathematics anxiety in their backgrounds" (p. 11). Because of findings like this, there has been a call to look deeper into mathematics *teaching* anxiety in preservice elementary school teachers (Brown et al., 2012; Haciomeroglu, 2014; Hunt & Sari, 2019).

The goal of this research was to explore this disconnect, examine mathematics teaching anxiety in preservice elementary school teachers, and investigate its relationship with mathematics anxiety and mathematics teacher efficacy. Specifically, this research aimed to answer the following question and sub-questions:

1. What roles do mathematics teaching anxiety, mathematics anxiety, and mathematics teacher efficacy have on preservice elementary school teachers?
2. What is the relationship between mathematics teaching anxiety, mathematics anxiety, and mathematics teacher efficacy?
3. How are varying levels of mathematics teaching anxiety, mathematics anxiety, and mathematics teacher efficacy experienced in elementary school preservice teachers?

Literature Review

This research involves three main constructs: mathematics teaching anxiety, mathematics anxiety, and mathematics teacher efficacy. This literature review will serve as a synopsis for each of these constructs and their relation to each other.

Mathematics Teaching Anxiety

When compared to mathematics anxiety and mathematics teacher efficacy, mathematics teaching anxiety is a relatively new endeavor, although research has shown a negative correlation between mathematics teaching anxiety and elementary students' mathematics achievement (Hadley & Dorward, 2011). A common problem with research in mathematics teaching anxiety is the lack of distinction with mathematics anxiety. Often, in research exploring the experiences of preservice and inservice teachers teaching mathematics in the classroom, researchers use instruments focused on measuring mathematics anxiety where mathematics teaching anxiety appears to be closer aligned with their research questions (Boyd, et al., 2014; Stoehr, 2017; 2019).

One of the first cases of research on mathematics teaching anxiety was done by Levine (1993). In this study, twenty-eight preservice elementary school teachers were asked to report on their prior mathematical education experience, anticipated teaching style, and anxiety for teaching mathematics prior to and after completing a mathematics methods course. Levine found that mathematics teaching anxiety was reduced after the methods course and that teachers with low mathematics anxiety anticipated teaching in a primarily student-orientated teaching style. Both findings do not speak much to the impact mathematics teaching anxiety could have on teachers.

Peker (2009) put the spotlight back on mathematics teaching anxiety by looking at the different levels of mathematics teaching anxiety. Peker measured 506 preservice teachers' levels of mathematics teaching anxiety and compared this to their learning style preferences. Peker found that convergent learners (learners who learn by combining abstract conceptualization with active experimentation) had less mathematics teaching anxiety compared to divergent learners (learners who learn by combining concrete experience with reflective observation). Unfortunately, there was no mention of mathematics teacher efficacy or mathematic anxiety.

An initial effort to distinguish mathematics teaching anxiety from mathematics anxiety was done by Brown et al. (2011). Fifty-three preservice elementary school teachers were asked to self-report using reflective writing after teaching a minimum of three elementary mathematics lessons at local elementary schools. These reflections were analyzed and coded for common themes. The results from this study showed that one-third of the preservice teachers reported having high mathematics anxiety but did not experience mathematics teaching anxiety. Individuals who were identified as having no mathematics anxiety, but high mathematics teaching anxiety described the difficulty of explaining their mathematics knowledge in ways that could be understood by the students. This again shows the need to separate and compare mathematics teaching anxiety and mathematics anxiety.

With mathematics teaching anxiety being a relatively new area of research, very few instruments have been developed to measure the construct. A commonly used instrument is the Mathematics Teaching Anxiety Scale developed by Peker (2006). The Mathematics Teaching Anxiety Scale is comprised of twenty-three 5-point Likert scale items and has four factors: anxiety caused by content knowledge, anxiety caused by self-confidence, anxiety caused by attitude towards teaching mathematics, and anxiety caused by methodological knowledge. This scale was originally developed and implemented in Turkish and has been used with English-speaking participants (Adeyemi, 2010). Unfortunately, even after spending copious time translating this instrument, Adeyemi reported confusion and social discrepancies between the English and Turkish translations and Adeyemi claims could have resulted in less-than-optimal results. Overall, I believe that Adeyemi was rigorous in her translation methodology, but I did not feel comfortable using her translated instrument without further evidence supporting its reliability and validity.

In addition to the Mathematics Teaching Anxiety Scale (Peker, 2006) described above, a second Mathematics Teaching Anxiety Scale was developed using elementary school teachers in Turkey (Sari, 2014). This 23-item scale was originally published in Turkish and was found to contain three factors: anxiety regarding math teaching processes, anxiety regarding math content knowledge, and anxiety related to math self-efficacy. A recent study by Hunt and Sari (2019) translated this Mathematics Teaching Anxiety Scale to English and used this to measure mathematics teaching anxiety in 127 inservice and preservice elementary school teachers across the UK. This translated scale was not available at the time of data collection for this research, but an initial review of Hunt and Sari's work seems very promising.

Mathematics Anxiety

Preservice teachers have been identified as an at-risk group for mathematics anxiety (Bursal & Paznokas, 2006; Gresham, 2009; Novak & Tassell, 2017). Evidence suggests that high levels of mathematics anxiety in preservice teachers can lead to poor mathematical performance (Gresham, 2009), increased levels of mathematics anxiety in their future students (Beilock et al., 2010; Vinson, 2001), and a higher probability of using traditional teaching methods such as lecturing, devoting more time to seatwork, and avoidance of using engaging unstructured teaching methods such as implementing mathematical manipulatives and asking open-ended questions (Bursal & Paznokas, 2006; Finlayson, 2014; Gresham, 2007; Vinson, 2001).

Studies have shown a statistically significant reduction in preservice elementary school teachers' levels of mathematics anxiety after a methods course (Gresham, 2007; Reid et al., 2018; Sloan, 2010), but there is evidence to suggest that this reduction is not permanent. Gresham (2018b) surveyed and interviewed 10 inservice teachers who were a part of a study 5 years prior that involved the levels of mathematics anxiety in preservice teachers before and after a methods course. Gresham found that, although there was an initial reduction in mathematics anxiety, all 10 of the inservice teachers had their mathematics anxiety return during their future teaching. This serves as evidence showing that mathematics anxiety is not easily reduced.

Mathematics Teacher Efficacy

Mathematics teacher efficacy stems from Bandura's (1986) self-efficacy and social cognitive theory. Bandura (1977) believed that efficacy beliefs were dependent on the context that the individual was in. For example, an individual may have high levels of efficacy when driving a car but have very low levels of efficacy when repairing a car. When dealing with teaching mathematics, we have mathematics teacher efficacy, the extent to which a teacher believes they have the ability to affect a student's mathematical performance when teaching mathematics.

Research has shown that, when faced with challenges during the teaching process, teachers with low levels of teacher efficacy put forward less effort and perseverance compared to their highly efficacious counterparts (Beilock et al., 2010; Gavora, 2010), use poor instructional strategies, and show little willingness to embrace innovation in their classroom (Swars et al., 2006). Mathematics methods courses have shown to increase preservice elementary school teachers' levels of mathematics teacher efficacy (Charalambous et al., 2008; Swars et al., 2006; Utley et al., 2005) as well as upon completion of a mathematics content course (Alsup, 2004).

Mathematics teacher efficacy has been shown to be associated with a teacher's past experiences as a learner of mathematics (Brown, 2012; Swars, 2005) and is often correlated to their relations with their past mathematics teachers and/or to their parent's relationship with mathematics. This relationship points towards mathematics teacher efficacy being cyclical in nature—a teacher with poor mathematics teacher efficacy negatively impacts their students and potentially creates a future teacher with low levels of mathematics teacher efficacy.

Correlations Between the Constructs

It is common to see mathematics anxiety and mathematics teacher efficacy examined together. Research has shown a negative correlation between the two constructs (Bursal & Paznokas, 2006; Gresham, 2008, 2018a), that is to say that as a preservice teacher's mathematics anxiety raises, their efficacy to teach mathematics lowers. Recent efforts have been made to examine mathematics teaching anxiety in preservice and inservice elementary school teachers (Adeyemi, 2010; Brown et al., 2011; Haciomeroglu, 2014; Olson & Stoehr, 2019; Peker & Ertekin, 2011; Unlu et al., 2017) with results indicating a negative relationship with mathematics efficacy (Ural, 2014) and mathematics teacher efficacy (Peker, 2016).

In regard to mathematics teaching anxiety and its relationship with mathematics anxiety, it is easy to assume that an individual with high levels of mathematics anxiety would naturally have high levels of mathematics teaching anxiety but the small amount of literature exploring this relationship is seemingly undecided. In a study involving 316 Turkish preservice teachers, Peker and Ertekin (2011) found a moderate positive relationship between mathematics anxiety and mathematics teaching anxiety. Additionally, Haciomeroglu (2014) surveyed 260 elementary school preservice teachers and found similar results.

Contradicting these results, Brown et al. (2011) examined written reflections from 53 elementary preservice teachers who reported having high mathematics anxiety. They found that preservice elementary school teachers who reported having high mathematics anxiety did not experience mathematics teaching anxiety. The researchers go as far as to create quadrants labelled as follows: Quadrant One: No mathematics anxiety, no mathematics teaching anxiety; Quadrant Two: Yes mathematics anxiety, no mathematics teaching anxiety; Quadrant Three: No mathematics anxiety, yes mathematics teaching anxiety; and Quadrant Four: Yes mathematics anxiety and yes mathematics teaching anxiety. Each of the quadrants had a minimum of nine of the 53 preservice teachers in them showing a wide range of experiences with mathematics anxiety and mathematics teaching anxiety.

As you can see above, mathematics teaching anxiety is a new but evidently important construct in elementary preservice teachers. Mathematics teaching anxiety plays a role in mathematics teacher

efficacy and mathematics anxiety—ultimately contributing to classroom performance. The goal of this research is to add to this conversation and work to improve preservice teacher mathematics education.

Methods

This section will outline the methods that were chosen to best address the research questions listed above. First the research design will be described, followed by a description of the participants and their context, the instruments used, and finally the methods of data analysis.

Research Design

A modified version of an explanatory sequential mixed methods design (Creswell & Plano Clark, 2007) with three phases was used. A mixed methods design was used to help gain a deeper and broader understanding compared to a qualitative or quantitative only approach (McKim, 2017). The first phase involved the distribution of a questionnaire containing demographic questions, the Revised Mathematics Anxiety Rating Scale (Alexander & Martray, 1989), a modified version of the Teaching Anxiety Scale (Parsons, 1973), a modified version of the Teachers' Sense of Efficacy Scale (Tschannen-Moran & Woolfold Hoy, 2001), and the open-ended question: "Tell me about an experience you had during your teacher education program learning (in class or on a placement) that might have come to mind while completing this survey." This questionnaire was distributed to preservice teachers at six universities across Ontario, Canada.

The second phase of this study consisted of an initial set of semi-structured interviews with preservice elementary school teachers from the survey who agreed to be interviewed. The interview was comprised of 10 questions and was conducted in person or via a video chat program such as Skype or Zoom. The purpose of these questions was to gain a better understanding of the preservice teachers' relationships with mathematics and teaching mathematics.

For the third phase, preservice teachers who were interviewed from phase two were contacted for an additional interview. This second interview was used to gather further information about mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy that might have been missed or undeveloped in their initial interview. The same interview protocol from phase two was used for phase three with the addition of individual notes for each interviewee based on the results from the initial analysis of their first interview data.

Participants

The participants of this study were preservice teachers enrolled in a Primary-Junior track program in a Faculty of Education across six major universities in Ontario, Canada. Upon graduation, these preservice teachers will be qualified to teach in kindergarten to grade six classrooms across Ontario. A total of 185 preservice elementary school teachers responded to the questionnaire (29%, 28%, 17%, 14%, 6%, and 6% from each of the six universities) distributed in phase one with 87% identifying as female. For phase two, 16 participants agreed to be interviewed with six of these participants agreeing to be involved in the second round of interviews for phase three. The 16 interviewees from phase one were relatively equally distributed across five of the initial six universities and the six interviewees from phase three were from four of the initial six universities.

It is important to understand a bit of background to gain a better understanding of the preservice teachers used in this study. Elementary school teachers in Ontario are expected to teach students from the age of 4 to 11. To be certified as an elementary school teacher in Ontario, preservice teachers are not required to have any post-secondary mathematics courses, they do not need to complete a mathematics

content course in their education program, and although there is the potential to have a mandatory mathematics proficiency test in Ontario, at the time of data collection for this research, this test was not mandatory.

Elementary teacher education in Ontario is typically a 2-year program with some universities offering a 16-month expediated program. Their time spent in the teacher education program is comprised of time learning at a Faculty of Education and time gaining experience teaching under the supervision of an associate teacher in an elementary classroom. The length of the time spent in the elementary classroom varies from university to university, preservice teachers are not forced to teach mathematics during their placement, and due to distribution of the questionnaire being spread out over a 3-month period due to varied ethical clearance, the participants in this research had varying levels of teaching experience.

Instrumentation

The questionnaire distributed in phase one was comprised of demographic questions, three separate scales used to measure mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy, and one open-ended question. The Revised Mathematics Anxiety Rating Scale (RMARS) developed by Alexander and Martray (1989) was used to measure preservice teachers' levels of mathematics anxiety. The RMARS is a modified version of The Mathematics Anxiety Scale (MARS) developed by Richardson and Suinn (1972) and reduces the 98-item MARS to a more digestible 25-item scale with the RMARS. The RMARS is made up of 25 items on a 5-point Likert scale and has three subconstructs: mathematics test anxiety, numerical task anxiety, and mathematical course anxiety.

A modified version of the Teaching Anxiety Scale (TCHAS) developed by Parsons (1973) was used to measure mathematics teaching anxiety. Due to the relatively under researched nature of mathematics teaching anxiety, there is no prominent tool used to measure this construct. Because of this, Parson's Teaching Anxiety Scale TCHAS(2)-25 (one of two separate scales developed by Parson to measure teaching anxiety) was adopted, and questions were modified to fit the context of a mathematics classroom. For example, the question "I feel uncertain about my ability to improvise in the classroom setting" was changed to "I feel uncertain about my ability to improvise in a *mathematics* classroom setting." The TCHAS is comprised of 25 items on a 5-point Likert scale.

For measuring preservice teachers' mathematics teacher efficacy, a modified version of the short form of Tschannen-Moran and Woolfolk Hoy's (2001) Teachers' Sense of Efficacy Scale (TSES) was used. Similar to the modification made above to the TCHAS, the TSES was modified by specifying the context to a mathematics classroom. The TSES consists of 12 items on a 9-point Likert scale and has three underlying constructs: efficacy for instructional strategies, efficacy for classroom management, and efficacy for student engagement.

For the interviews, a protocol containing 10 open-ended questions was developed and structured to be approximately 1 h in length. The development of the interview questions was guided by the collection of literature surrounding mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy which served as the foundation for the conceptual framework of this research. The purpose of the interview was to gain a better understanding of preservice teachers' relationship with mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy.

Data Analysis

Data collected from the online questionnaire were entered into the data analysis software SPSS Statistics Version 25, with reverse coding performed as required. Initially, descriptive statistics, such as overall means and standard deviations for the RMARS, TCHAS, and TSES scales, were computed. These statistics gave an understanding of the overall landscape of the constructs in preservice elementary school

teachers across Ontario. Before any additional analyses was done, factor analyses and reliability checks were completed to ensure the RMARS, TCHAS, and TSES were behaving as expected. Afterwards, the means for the RMARS, TCHAS, and TSES scales were computed for each individual and used to place participants into categories based on mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy (high, moderate, or low anxiety/teaching anxiety/teacher efficacy).

With the participants categorized into high, moderate, or low for each of the RMARS, TCHAS, and TSES, analyses of variances (ANOVAs) were computed for the groupings for each category. This analysis served to help uncover any differences between the high, moderate, and low groups for each construct and contrasts were used to see which groups differed (Field, 2018). Multiple separate ANOVAs were computed instead of a multivariate analysis of variance (MANOVA) because of the structure of the research questions. In a study examining the suitability of using multiple ANOVAs versus a single MANOVA, Huberty and Morris (1989) identified four situations where multiple ANOVAs are appropriate over a single MANOVA, two of which apply directly to this study: (1) when the research is exploratory in nature and (2) when some or all of the outcome variables under the current study have been previously studied in univariate contexts.

For the qualitative data analysis interviews from phase two and phase three were recorded, transcribed, and imported into the qualitative analysis program *NVivo* Version 12. Mathematics anxiety and mathematics teacher efficacy are constructs that have been well researched, whereas mathematics teaching anxiety has very little prior research. Therefore, emergent coding (Creswell, 2007) was used. This allowed for the codes to be generated which were then further compiled into themes. Given that the focus of this research was to examine the relationship between mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy, the qualitative analysis procedure was designed to isolate one construct and examine it through the lens of another. For example, all individuals with high mathematics teacher efficacy were grouped together and then, these interviews were examined by looking for instances of mathematics anxiety and then coded again separately for mathematics teaching anxiety. This coding procedure allowed for a perspective of how an individual with high mathematics teacher efficacy experiences the other two constructs. Triangulation, member-checking, and inter-rater reliability were used to validate these findings.

Results

The following section will outline the results found from the quantitative data followed by the qualitative data. While this is a mixed methods study, the results will be presented separately and then mixed in the "15" and "16" sections.

Quantitative Results

The RMARS is a multidimensional instrument. As such, a confirmatory factor analysis (CFA) was carried out using SPSS Version 25 and AMOS. The root mean square error (RMSEA) is a popular measure of fit for a CFA. The RMARS from this study yielded an RMSEA of 0.101 which is outside of the standard for a proper fitting model. Therefore, an exploratory factor analysis (EFA) was computed for the RMARS. For the EFA, a principal factor analysis was conducted on the 25 items with oblique rotation (oblique rotation was chosen due to the expectation that the factors are correlated). The Kaiser–Meyer–Olkin (KMO) measure verified sampling adequacy with KMO = 0.96 and the results indicated that the RMARS is a valid measure. The RMARS has three factors: mathematics test anxiety, numerical task anxiety, and mathematics course anxiety. An analysis of the reliability using

Cronbach's alpha for these three factors yielded $\alpha = 0.969$, $\alpha = 0.878$, and $\alpha = 0.858$, respectively, determining the RMARS to be a reliable measure.

An EFA was done on the TCHAS to determine validity of the instrument. The principal axis factor analysis was done on the 25 items of the TCHAS using an orthogonal rotation as it was expected that the TCHAS is a unifactor instrument. The factor analysis returned five factors—one large factor and four small factors. These smaller factors had no discernable themes. Therefore, a second EFA was computed except parameters were set to force a single factor output (rotation is irrelevant here due to one factor output). The KMO for the single factor EFA verified sampling adequacy with KMO = 0.91 and all of the factors properly loaded one a single factor verifying the validity of the instrument. An overall Cronbach alpha for the TCHAS was computed to be $\alpha = 0.969$, indicating that the TCHAS was a reliable instrument.

The TSES is a multidimensional instrument with three subconstructs. A CFA was done on the results of the TSES. The results of the CFA yielded an RMSEA of 0.068, which is between a good and mediocre fit of the anticipated loadings (MacCallum et al., 1996). The three subconstructs of the TSES are efficacy for instructional strategies, efficacy for classroom management, and efficacy for instructional strategies. To test for reliability, Cronbach's alpha was computed for each of these subfactors and was calculated to be $\alpha = 0.871$, $\alpha = 0.863$, and $\alpha = 0.855$, respectively, determining that the TSES was a reliable instrument.

To determine the relationship between mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy, a two-tailed bivariate correlational analysis was done with the RMARS, TCHAS, and TSES. Table 1 shows the results of this analysis with all insignificant findings removed for easier reading. While an interpretation of the findings will be presented in the "15" and "16" sections, it is important to note at this point that there is a lack of correlation between mathematics anxiety and mathematics teacher efficacy.

For a better interpretation of the differences between groups of high, medium, and low mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy, multiple ANOVAs were computed with the Gabriel procedure as a post hoc test. When investigating if there was a significant difference between an individual's scores based on their level of mathematics anxiety (RMARS) and their level of mathematics teaching anxiety (TCHAS), it was found that individuals with low mathematics anxiety had significantly lower mathematics teaching anxiety than those with average mathematics anxiety ($F(2,182) = 57.99$, $p < 0.01$) and high mathematics anxiety ($F(2,182) = 57.99$, $p < 0.01$). Additionally, individuals with average mathematics anxiety had significantly lower levels of mathematics teaching anxiety than those with high levels of mathematics anxiety ($F(2,182) = 57.99$, $p < 0.01$).

Investigating if there was a significant difference between an individual's score based on their level of mathematics teacher efficacy (TSES) and mathematics teaching anxiety (TCHAS), it was found that individuals with low mathematics teacher efficacy had significantly higher mathematics teaching anxiety than those with average mathematics teacher efficacy ($F(2,182) = 15.275$, $p < 0.01$) and high mathematics teacher efficacy ($F(2,182) = 15.275$, $p < 0.01$). Additionally, individuals with average mathematics teacher efficacy had significantly higher levels of mathematics teaching anxiety than those with high mathematics teacher efficacy ($F(2,182) = 15.275$, $p < 0.01$).

When determining if there was a significant difference between an individual's score based on their level of mathematics anxiety (RMARS) and mathematics teacher efficacy (TSES), it was found that there was a significant difference in mathematics teacher efficacy scores amongst individuals with low levels of mathematics anxiety and those with average levels of mathematics anxiety ($F(2,182) = 3.441$, $p < 0.05$), but no significant difference elsewhere. Notably, the individuals who were considered to have high mathematics anxiety had no significant difference in terms of their mathematics teacher efficacy than individuals with average or low mathematics anxiety.

Table 1 Simplified correlations for RMARS, TCHAS, and TSES

	RMARS *Math test anxiety*	RMARS *Numerical task anxiety*	RMARS *Math course anxiety*	RMARS *Total*	TCHAS *Total*	TSES *Efficacy for instructional strategies*	TSES *Efficacy for classroom management*	TSES *Efficacy for student engagement*	TSES *Total*
RMARS *Math test anxiety*					.690**	−.271**			−.159*
RMARS *Numerical task anxiety*					.508**				
RMARS *Math course anxiety*					.565**	−.251**		−.172*	−.187*
RMARS *Total*					.682**	−.240**			
TCHAS *Total*						−.457**	−.285**	−.373**	−.417**

Note that only significant correlations are shown

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Qualitative Results

The results presented here in the qualitative analysis use the data collected from the short answer question from phase one, the interviews from phase two, and the repeat interviews from phase three. Using the results from the questionnaire, participants were categorized as having either high, medium, or low levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy. This allowed researchers to categorize the participant data.

This categorization allowed for participants to be in more than one category (e.g., a preservice teacher with high mathematics anxiety, high mathematics teaching anxiety, and average mathematics teacher efficacy would be categorized in the high mathematics anxiety category and the high mathematics teaching anxiety category, therefore being a part of two groups). For the category of a student with moderate mathematics anxiety, the data was coded once using emergent coding without any lens of a construct. The themes generated from this analysis can be seen in Table 2. A description for each code will be provided below.

High Mathematics Anxiety (n = 30) Though a Mathematics Teaching Anxiety Lens

Developing Strategies to Cope Preservice teachers with high levels of mathematics anxiety indicated that they were aware of these feelings and they made the necessary preparations to cope with their mathematics anxiety when teaching. Preservice teachers talked about breaking down the mathematics lesson into more digestible chunks for their own comprehension and for their teaching. Other preservice teachers talked about devoting extra time to finding teaching resources to help them with their teaching. One preservice teacher said, "there was probably a two- or three-day period where I spent two or three hours trying to make sure I had everything I needed, but I am much better now." Although these preservice teachers struggle with their mathematics anxiety, instead of shying away from teaching mathematics, they work harder to overcome these feelings and prepare diligently for their teaching.

High Mathematics Anxiety (n = 30) Through a Mathematics Teacher Efficacy Lens

Pushing Through the Anxiety Preservice teachers with high levels of mathematics anxiety knew they had a negative relationship with mathematics, but they were also aware of the importance of modelling a

Table 2 Themes generated from qualitative analysis

	Mathematics anxiety lens	Mathematics teaching anxiety lens	Mathematics teacher efficacy lens
High mathematics anxiety bin		Developing strategies to cope	Pushing through anxiety
Low mathematics anxiety bin		Relation to peers	No themes found
		Bringing the passion	
High mathematics teaching anxiety bin	Good student, poor student experience		Reliance on resources
Low mathematics teaching anxiety bin	Mathematics content knowledge		Overcoming early teaching obstacles
High mathematics teacher efficacy bin	Overcoming early teaching obstacles	Enjoyment of mathematics	
Low mathematics teacher efficacy bin	Small scale confident, large scale worried	Comfortability with mathematics	
	Taught one way, asked to teach another		
Average bin	Optimistic hesitance		

positive mathematical mindset to their students. For example, one preservice teacher said, "I know that, by modelling a positive attitude, it will be picked up the same way as modelling a negative attitude." Similarly, when discussing the importance of modelling perseverance with mathematics, one preservice teacher wrote "their behaviour will be similar to mine and even if they are not the best at math and even if they did not enjoy that particular thing, they will try." These preservice teachers knew their personal relationship with mathematics was poor, but they worked to make sure this was not the same for their students. These teachers believed they could push through their negative feelings and model a positive attitude for their students and their learning of mathematics.

Low Mathematics Anxiety (n = 39) Through a Mathematics Teaching Anxiety Lens

Relation to Their Peers Preservice teachers with low levels of mathematics anxiety made constant reference to their perceived ability to do and teach mathematics compared to their peers in their teacher education program. When talking about their mathematical ability and ability to teach mathematics, one preservice teacher went on to say, "I was really advanced, and I have a hard time saying that about my counterparts" and "I am much more confident and better at math than a lot of my colleagues." With low mathematics anxiety, these preservice teachers are more comfortable than their peers with the content being discussed in their mathematics curriculum class. This could lead them to feeling as leaders in the class and generally "above the curve" or better than average in mathematics teaching capabilities.

Bringing the Passion Preservice teachers with low levels of mathematics anxiety talked about their passion for mathematics being contagious. They believed their comfortability with the content increased their ability to teach mathematics as they could "bring that extra piece" to their mathematics classroom. These preservice teachers were confident in their ability to leverage their low mathematics anxiety to bolster their ability to teach.

Low Mathematics Anxiety (n = 39) Through a Mathematics Teacher Efficacy Lens

No Themes Found When looking through the lens of mathematics teacher efficacy, preservice teachers with low levels of mathematics anxiety were seemingly split into a dichotomy. One side of this division talked about their comfortability with mathematics being a hindrance to their teaching:

> I taught the geometry unit and I struggled at first because the math just made sense. It was difficult for me to put myself into the mindset of someone who are struggling with something. It was a while before I was able to understand where it was students were getting stuck and how to tackle that part of it.

For these preservice teachers, their levels of mathematical teaching efficacy were lowered by their comfort with mathematics.

There were the preservice teachers who believed that their low levels of mathematics anxiety were a crutch that they could call upon at any time during their teaching if things were not going smoothly. Preservice teachers showed examples of being able to quickly relate a mathematics problem to a particular student's interest if that student was showing disinterest. This difference in experience will be discussed further in future sections.

High Mathematics Teaching Anxiety (n = 33) Through a Mathematics Anxiety Lens

Good Student, Poor Student Experience Preservice teachers with high levels of mathematics anxiety interestingly had neutral to positive things to say about mathematics. Notably, these preservice teachers

talked about negative experience involving their teachers, classrooms, and school management surrounding mathematics. One preservice teacher passionately recounted a high school teacher telling them "you should not take math anymore," while other remembers their mathematics teacher as someone who "gave off the 'I do not like math and we are only doing this because we have to' sort of vibe."

This theme was unexpected as prior research connects an individual's prior experiences with mathematics to their future relationship with mathematics (Bates et al., 2013). Furthermore, these preservice teachers indicated a positive relationship with mathematics, yet high levels of mathematics teaching anxiety. This may be due to the preservice teachers' unwillingness to be a poor mathematics teacher like the one they remember from when they were students. These preservice teachers know the impact a poor experience in the mathematics classroom can have on a student and the potential negative impact they can have if they are not a "good" mathematics teacher.

High Mathematics Teaching Anxiety (n = 33) Through a Mathematics Teacher Efficacy Lens

Reliance on Resources Preservice teachers with high levels of mathematics teaching anxiety consistently made mention of their use of resources to help with their teaching. These preservice teachers discussed the benefits of having a "tested" product that they knew worked and was founded in proper mathematical teaching principles. These preservice teachers believed that by utilizing the resources made available to them they were able to quell their feelings of mathematics teaching anxiety and ultimately increase their mathematics teacher efficacy.

Low Mathematics Teaching Anxiety (n = 34) Through a Mathematics Anxiety Lens

Mathematical Content Knowledge When discussing the teaching of mathematics, many of the preservice teachers with low mathematics teaching anxiety focused on the mathematics content knowledge of themselves and their peers. Interestingly, some stressed the positive relationship between content knowledge and teaching: "I think the better you do academically in math, the better you will be at teaching math overall," while others claimed there was a negative correlation: "I would say you almost have to wipe everything you have ever learned and relearn it the way that students are learning it." Regardless of their stance, many of the low mathematically anxious preservice teachers put importance on mathematical content knowledge.

Low Mathematics Teaching Anxiety (n = 34) Through a Mathematics Teacher Efficacy Lens

Overcoming Early Teaching Obstacles Preservice teachers with low mathematics teaching anxiety discussed overcoming obstacles early in their teaching experiences. These obstacles were primarily challenges revolving around pedagogical practices. For example, one preservice teacher talked about being overwhelmed by the amount of teaching tools, resources, and best teaching practices at the beginning of their practicum. Fortunately, this preservice teacher quickly realized that, while these tools all have the potential to be useful, they did not have to use all of them all of the time. Another preservice teacher talked about struggling to keep their students engaged during a math lesson. After an initial struggle, they described having an "ah-ha" moment and their efficacy to teach mathematics quickly growing afterwards.

These moments of early struggle and subsequent triumph speak to the link between anxiety and efficacy. Overcoming an early obstacle is an early win for the preservice teacher to attach themselves to. When another problem comes along, they do not panic because they have been in a situation like this before.

Instead, they engage the problem with confidence, subsequently lowering their mathematics teaching anxiety.

High Mathematics Teacher Efficacy (n = 34) Through a Mathematics Teaching Anxiety Lens

There was a large amount of overlap between the population of preservice teachers with low mathematics teacher efficacy and those with low levels of mathematics teaching anxiety. Because of this, the theme that emerged from the population of preservice teaching with high mathematics teacher efficacy was *overcoming early teaching obstacles*—the same as above. For brevity, this theme will not be repeated here.

High Mathematics Teacher Efficacy (n = 34) Through a Mathematics Anxiety Lens

Enjoyment of Mathematics As expected, preservice teachers with high levels of mathematics teacher efficacy showed low levels of mathematics anxiety and an overall enjoyment of mathematics. These preservice teachers talked about mathematics as "something that came naturally to me" or something that has "always been a strong point." The ability to comfortably rely on mathematics content knowledge to supplement their mathematics teaching practices boosts the preservice teachers' levels of mathematics teacher efficacy.

Low Mathematics Teacher Efficacy (n = 32) Through a Mathematics Teaching Anxiety Lens

Small Scale Confident, Large Scale Worried A large portion of preservice teachers with low mathematics teacher efficacy had average or low levels of mathematics teaching anxiety. It appeared that preservice teachers in this category were not worried about the day-to-day teaching of mathematics in their classroom, rather they were worried about larger more holistic issues in teaching. These issues included differentiated instruction, classroom management, and student engagement. For example, one preservice teacher shared their concerns with teaching mathematics as "feeling like there is this pressure to reach every student" and "how to engage all of the learners." This could explain the disconnect found between mathematics anxiety and mathematics teacher efficacy as the reduction in mathematics teacher efficacy was not due to mathematical content knowledge, but instead due to larger issues of teaching mathematics.

Taught One Way, Asked to Teach Another Another consistent theme amongst preservice teachers with low mathematics teacher efficacy was the feeling that they were being asked to teach mathematics in a way that they were not taught. For example, one preservice teacher shared this experience:

> I do not know when this new math started but I certainly never had manipulatives and that stuff in my math. We learned by rote memorization and by worksheet after worksheet and that was that. Fortunately, that worked for me, but I personally have more anxiety because of all of these manipulatives and not being sure whether I can manage those manipulatives and those behaviours in the classes and keep the kids on task because that is not the way I learned. So, trying to teach kids to learn in a way that I never learned is mindboggling.

It is promising to hear that preservice teachers are cognizant of the way they are teaching mathematics and they are trying to teach in a way that is most effective for their students, but unfortunately this is also causing lower mathematics teacher efficacy.

Low Mathematics Teacher Efficacy (n = 32) Through a Mathematics Anxiety Lens

Comfortability with Mathematics Contrary to what one would expect, the majority of preservice teachers in this study had little to no negative experiences with mathematics. When asked about their relationship with mathematics, the response was often "I like math in general," "I would say I like math," and "we get along just fine." Similar to above, when seeking a cause for the low levels of mathematics teacher efficacy, it appears that their efficacy was hindered by their knowledge of how to teach mathematics, not their knowledge surrounding the content in mathematics as their issues stemmed from teaching practices, not their personal relationship with mathematics.

Moderate Student (n = 50)

Optimistic Hesitance Preservice teachers in this category scored *average* on all three constructs. When coding this group, there was a clear theme of optimistic hesitance throughout. Preservice teachers showed confidence and excitement but knew the challenges of teaching and had some reservation. For example, preservice teachers in this category believed they had the tools necessary to teach but were aware that they still had a lot to learn and would always be learning throughout their career. Additionally, preservice teachers discussed their enjoyment with mathematics…up until a certain point. There was constant mention of preservice teachers enjoying mathematics up until their senior grades of high school where either they lost interest or it became too challenging. These preservice teachers were aware that teaching mathematics takes a lot of work, but they seemed optimistic about the challenge.

Discussion

With the quantitative and qualitative results presented above, this section aims to answer the overarching research question by mixing and interpreting these results together. Mathematics teaching anxiety and mathematics anxiety have been shown in past research to be positively correlated—a teacher with high levels of mathematics teaching anxiety is likely to have high levels of mathematics anxiety (Adeyemi, 2010; Haciomeroglu, 2014; Peker & Ertekin, 2011; Unlu et al., 2017). The findings from the research are in alignment with this conclusion. From the quantitative results, we see a positive correlation between mathematics anxiety (as measured by the RMARS) and mathematics teaching anxiety (as measured by the TCHAS). The qualitative results bolster this finding as we see that preservice teachers with low levels of mathematics anxiety talked about *bringing the passion* of mathematics to their teaching, lowering their mathematics teaching anxiety. Preservice teachers with high levels of mathematics anxiety seemingly do not have this passion for mathematics to fall back on. Instead, these preservice teachers talked about having to rely on resources and being proactive in their teaching practice.

In this research, mathematics teaching anxiety and mathematics teacher efficacy were found to be negatively correlated—in alignment with the limited research done on this topic (Peker, 2016; Unlu et al., 2017).

From the quantitative analysis, we see a moderately negative correlation between mathematics teaching anxiety (as measured by the TCHAS) and mathematics teacher efficacy (as measured by the TSES). We see these results echoed in the qualitative results as well. Preservice teachers with low levels of mathematics teacher efficacy discussed that they were small scale confident but large scale worried about their teaching and frustrated with having been taught one way but asked to teach another. We see here that pedagogical issues are the main focus for these preservice elementary school teachers, not knowledge of mathematical content. They are worried about teaching the subject, not understanding it.

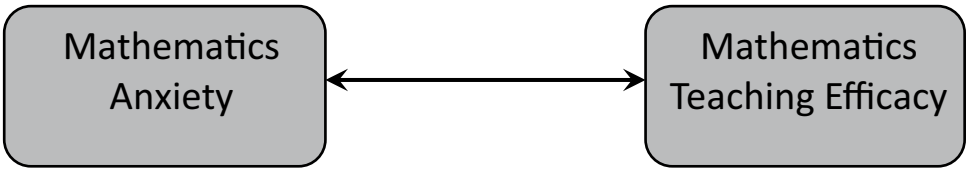

Fig. 1 Relationship between mathematics anxiety and mathematics teaching efficacy as observed in prior research

Unlike the prior two relationships discussed above, the evidence regarding the relationship between mathematics anxiety and mathematics teacher efficacy does not align with the current literature. It has been shown in previous work that mathematics anxiety is negatively correlated to mathematics teacher efficacy (Gresham, 2008; Swars et al., 2006; Unlu et al., 2017), but evidence from this research shows little to no correlation between the two constructs. In the quantitative data, we see the total score for the RMARS not correlated to the total for TSES and even the subconstructs between the two show little to no correlation. In the qualitative data, we see instances of this disconnect with preservice teachers pushing through their anxiety or instances of low mathematics anxiety actually causing poorer teaching practices as the preservice teachers cannot relate to their struggling students.

In the current literature, the understanding of the relationship between mathematics anxiety and mathematics teaching efficacy looks like Fig. 1 where mathematics anxiety is negatively correlated to mathematics teaching efficacy. This research introduced mathematics teaching anxiety and examined the interactions between all three constructs. An initial hypothesis of how these constructs would interact is given in Fig. 2. In this model, each construct has an influence over another in a triadic relationship. The results from this research contradict this hypothesis specifically due to the non-relationship found between mathematics anxiety and mathematics teacher efficacy.

A model like Fig. 3 could be a way in which we can model these three constructs and their interactions. In this model, we see that mathematics teaching anxiety and mathematics teacher efficacy are correlated (negatively) with each other, but mathematics anxiety is only correlated with mathematics teaching anxiety and has no direct correlation with mathematics teacher efficacy. This aligns with the results of this research but, at first glance, not with prior research that shows mathematics anxiety having a negative correlation with mathematics teacher efficacy. This could be because mathematics teaching

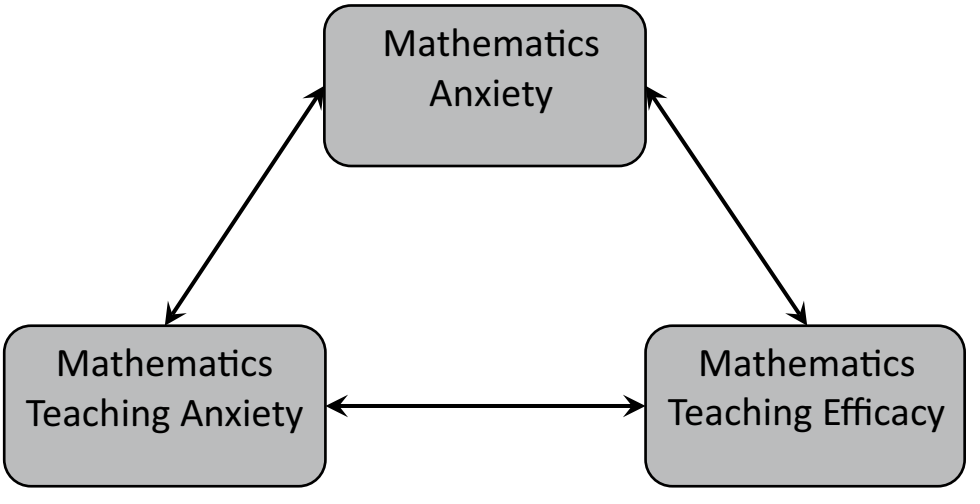

Fig. 2 Hypothesized relationship between mathematics anxiety, mathematics teaching anxiety, and mathematics teaching efficacy

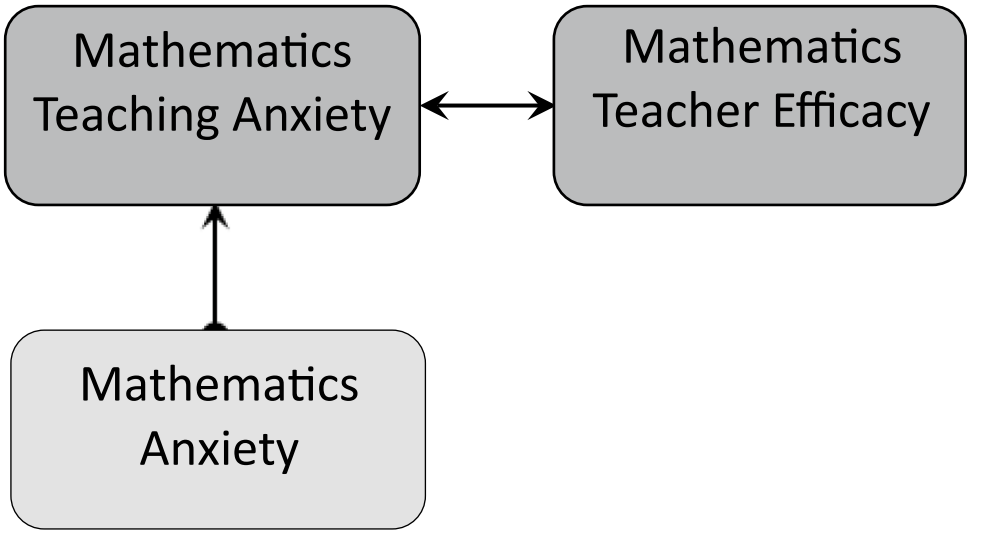

Fig. 3 Second proposed relationship between mathematics anxiety, mathematics teaching anxiety, and mathematics teaching efficacy

anxiety is being conflated with mathematics anxiety. When mathematics teaching anxiety is introduced to the conversation, a different picture could be emerging—one that looks closer to Fig. 3.

Currently, mathematics teaching anxiety is not a major part of the conversation in terms of preservice elementary school teachers' education but fortunately mathematics anxiety is a part of this conversation (especially considering Ontario's Mathematics Proficiency Test). The work done in the research presented above could serve as a steppingstone towards a deeper understanding of what impacts elementary school preservice teachers when they are teaching mathematics. Current efforts in improving elementary school preservice teachers' mathematics pedagogy rely on a model like that described in Fig. 1. Through efforts like mathematical content courses, preservice teacher educators hope to decrease mathematics anxiety, therefore increasing mathematics teaching efficacy and ultimately improving classroom instruction. Interestingly, the initial findings in this research suggest that mathematics content is not always the major concern for preservice elementary school teachers.

Improving elementary school preservice teachers' mathematical pedagogy using a model like that described in Fig. 3 would shift the emphasis put on decreasing mathematics anxiety towards decreasing mathematics teaching anxiety instead. I want to take a moment to clarify that I am not advocating for a complete disregard of mathematics anxiety. Instead, I am suggesting that reducing mathematics teaching anxiety could be the new primary goal—with reducing mathematics anxiety being a way to achieve that goal. Instead of introducing a mathematics content course focusing on mathematical content such as how to solve the addition and subtraction of fractions, should we instead begin a lesson by quickly reviewing the mathematical content then focusing primarily on the struggles and stresses of teaching addition and subtraction of fractions? In a preservice teacher mathematic education classroom, should the conversation shift from discussing how we feel when we do mathematics towards discussing how we feel when we teach mathematics?

While I do not think the evidence provided in this research alone can serve as strong enough evidence to shift how we think about preservice teacher mathematics anxiety, mathematics teaching anxiety, and mathematics teacher education, I do believe that the argument provided does advocate for a deeper investigation of mathematics teaching anxiety in elementary school preservice teachers. I believe that the anxiety to teach mathematics should be a bigger part of the conversation moving forward because it is impacting the preservice teachers.

Conclusion

With the results of this study, it would be a bold conclusion to assume that mathematics teaching anxiety should be the one and only focus in preservice elementary school teachers' mathematics pedagogy. Instead, I believe that the results of this study should serve as an initial step in raising the importance of mathematics teaching anxiety and advocate for mathematics teaching anxiety to become a bigger part of the conversation surrounding elementary school preservice teachers and their ability to effectively teach mathematics. Preservice teachers are resilient and resourceful and have found ways to help overcome their mathematics anxiety. Should we instead focus some of our efforts away from helping teachers become less anxious mathematicians and instead focus on helping our teachers become less anxious mathematics teachers? I believe this shift in perception would greatly improve preservice teaching and ultimately benefit elementary school students.

Moving forward, I would encourage more research to be done on preservice elementary school teachers and mathematics teaching anxiety. I think the next step in this endeavor would be to develop a more robust method for measuring mathematics teaching anxiety. With a standard and consistent tool for measuring mathematics teaching anxiety, more comparisons can be made, and a better conversation can be had.

This study does have limitations that should be considered before fully interpreting the results. First, due to the lack of response from some universities, only six of the possible 12 universities in Ontario were included in this study. Second, the preservice teachers interviewed in this study were voluntary and therefore represent a portion of the preservice teacher population that felt comfortable with discussing their relationship with mathematics. Finally, teacher education programs in Ontario differ in important aspects. Some programs are comprised of two 2-term years (8 months each) while other programs are four consecutive terms comprising a 16-month block for the program. Because of this variation in teacher education programs, the preservice teachers in this research were at varying points of completion in their teacher education and therefore had different experiences with teaching mathematics and also had varied mathematical backgrounds.

Declarations

Conflict of Interest The author declares no competing interests.

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