# 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 students 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 and 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. These results support using mathematics *teaching* anxiety as a measure for identifying preservice elementary

school teachers in need of help teaching mathematics ultimately leading to improved mathematics instruction in elementary school classrooms.

## Dedication

This dissertation is dedicated to my children Merik and Davis. I hope this piece of work stands as evidence that with hard work and determination, you can get through even the toughest challenges. I will love you both forever.

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There are many people who I must thank for getting me to this point. First, I would like to thank Dr. Jamie Pyper, my supervisor. Not only has he put up with over four years of my endless questions, but he has always been a caring and genuine individual who has provided me with both academic and non-academic guidance. I would also like to thank Dr. Rena Upitis and Dr. Holly Ogden, my thesis committee. I am grateful for all the time and effort they have contributed.

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# Chapter One – Introduction

## 1.1 Introduction

The purpose of this research was to understand how mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy impact Ontario preservice elementary school teachers' beliefs about their mathematics teaching practice. For some individuals, mathematics is synonymous with fear, dread, and anxiety. These negative feelings are normally manageable, as traditional mathematics—math driven by chalkboards, worksheets, and "solve for *x*"— is not part of a typical day for most people. Contrary to this scenario, for future elementary school teachers in Ontario, mathematics is unavoidable. What can be done for preservice elementary school teachers who dread mathematics? How are preservice teachers who are passionate for mathematics experiencing the elementary classroom compared to those that have mathematics anxiety?

Looking at the path it takes to become an elementary school teacher, it is not surprising that there are some preservice elementary school teachers with high levels of mathematics anxiety. To apply to become a certified elementary school teacher in Ontario, one must first complete an undergraduate degree and then complete a bachelor's degree of education afterwards. No university level mathematics courses are required to enter a teacher education program in Ontario. This means that the last required formal mathematics education in a preservice elementary school teacher's career as a student could have been in secondary school. This could leave a gap of at least six years from the last time they were required to study mathematics. If a preservice elementary school teacher is suffering from mathematics anxiety, they are often not encouraged or supported in resolving these feelings until their mathematics methods course or possibly not even until they are teaching in a classroom.

The Education Quality and Accountability Office (EQAO) has shown a steady decrease in mathematics achievement with learners in the primary and junior division with only 58% of the 2018-2019 primary cohort being at or above the provincial standard and only 48% of the 2018-2019 junior cohort being at or above the provincial standard (EQAO, 2019). This decrease in performance has put an increased demand on in-service and preservice elementary school teachers to effectively teach mathematics (Ontario Ministry of Education, 2018). Additionally, as of spring 2020, preservice elementary school teachers have been put under increasing pressure with the introduction of the Mathematics Proficiency Test—an examination of preservice elementary school teachers' mathematics content knowledge and pedagogical content knowledge—as a requirement to receive teaching accreditation in Ontario. This increase in teaching expectation carries with it an increase in potential stress and anxiety and can be problematic when many preservice elementary school teachers are already pushed to their academic and emotional limits (Harris, 2011).

Preservice elementary school teachers have a long history of experiencing higher levels of mathematics anxiety compared to other undergraduate students (Bursal & Paznokas, 2006; Harper & Daane, 1998; Hembree, 1990; Kelly & Tomhave, 1985). These high levels of mathematics anxiety in preservice elementary school teachers are not just detrimental to themselves, but to their future students as well. The potential for mathematically anxious teachers to pass their anxiety to their students creating mathematically anxious teachers in the future has been demonstrated (Brady & Bowd, 2005; Smith, 2004) and can cause a repeating cycle of mathematics anxiety. Because of this, more research and understanding are needed to address these concerns and better prepare our preservice elementary school teachers to teach mathematics.

The rest of this chapter outlines my research questions and provides a description of myself as a researcher. This chapter closes with a brief overview of the main concepts that have been discussed throughout this introduction.

## 1.2 The Research Question

When mathematics anxiety in the classroom is discussed, many assume the focus is on the students, but this is not necessarily the full picture. There are other individuals in the typical classroom that can be equally affected by mathematics anxiety—the teachers. One study of 261 early childhood and elementary school in-service teachers indicated that up to 95% of teachers experience moderate or high levels of mathematics anxiety (Gresham, 2017). This is concerning, as mathematics anxiety not only impacts the teacher but can influence the teacher's students as well. Mathematics anxiety in preservice elementary school teachers has been shown to have negative implications on students' academic success and mathematical beliefs (Bekdemir, 2010; Furner & Berman, 2005; Hembree, 1990; Sloan et al., 2002; Tobias, 1998; Vinson, 2001) and mathematics anxiety has also been shown to be cyclical in nature (Brady & Bowd, 2005; Smith, 2004) meaning mathematically anxious preservice teachers can potentially pass on their mathematics anxiety to their future students.

The present research aimed to understand how mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy are experienced by preservice elementary school teachers in Ontario. Preservice elementary school teachers were chosen as the focus of this study instead of in-service teachers because of access. By access, I mean not only the immediate benefit of being able to gather preservice elementary school teachers as participants compared to in-service teachers, but I also mean access in terms of being able to provide impactful education and professional development. Preservice teachers are at the beginning

stages of their career. A stage when they have greater access to resources, time, and support to improve their teaching practice compared to in-service teachers who—with their time being split between teaching, grading, planning, and their personal life—often cannot devote large amounts of time to continuing education (Osamwonyi, 2016). Because of these considerations, this research focuses on preservice elementary school teachers.

This research was guided by the following overarching question and sub-questions:

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

## 1.3 Myself as Researcher

Contrary to what one might expect, I come to this research of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy in preservice elementary school teachers with a background in mathematics but not in educational research or from an extensive background in elementary or secondary teaching. Mathematics has been a constant throughout my life. As a student, mathematics brought challenge, success, and joy. As a preservice teacher, mathematics is a place of comfort and confidence. As an individual, mathematics is a foundation to how I think. I am fortunate to have this relationship with mathematics, but I know this is not the case for others. My interests, passion, and education originate from mathematics. Throughout the time that I have studied mathematics at the undergraduate and graduate levels, I have

experienced varying levels of confidence. I was never a student who naturally excelled in mathematics. I had to work hard and as a result I was able to overcome challenges. I have experienced and overcome varying levels of mathematics anxiety and efficacy throughout my time as a student. Eventually I overcame these feelings of anxiety, but those experiences will always stick with me.

My time spent as a master's student studying mathematics coincided with friends completing their Bachelor of Education degree or already teaching in an elementary school. During conversations—in a search for a discussion topic on neutral ground—it was commonplace for the topic of discussion to end up at the teaching of mathematics. It was surprising to me how many preservice and in-service elementary school teachers willingly discussed their open dislike for mathematics and the teaching of mathematics. Unlike many other professions, mathematics is not something elementary school teachers can avoid. The Ontario Ministry of Education (2016) requires elementary school teachers to teach 300 instructional minutes of mathematics a week. During such conversations I wondered, how are these preservice and in-service elementary school teachers dealing with this conflict? How is their aversion towards mathematics affecting their teacher education and teaching practice? How is their dislike for mathematics going to affect their students and/or future students? These thoughts are what led me to this research of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy in preservice elementary school teachers. I have gone through what many perceive as the mathematical gauntlet, and I was able to make it out the other end with enjoyment for and appreciation of mathematics. I wanted to learn how I could help preservice elementary school teachers do the same.

While writing this dissertation and interpreting the results I was fortunate enough to have the opportunity to teach multiple mathematics education courses to preservice elementary school teacher candidates. These courses ranged from two-week summer courses to a year-long course and afforded me the privilege to teach and observe over 100 preservice elementary school teachers while they were learning about the teaching of mathematics. These experiences helped me better envision the preservice elementary school teachers I read about and interviewed for this research.

## 1.4 Mathematics Anxiety

Many people, both inside and outside of the field of education, have negative attitudes towards mathematics which can lead to severe mathematics anxiety (Hembree, 1990; Maloney & Beilock, 2012). Mathematics anxiety can be described as "feelings of tension or anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Tobias, 1993, p. 551). Often mathematics anxiety in adults and children manifests itself in mathematics avoidance. For many adults, mathematics in the form of numerical manipulation and solving mathematical problems is easily avoidable but for preservice and in-service elementary school teachers this is not the case.

There is an argument to be made that the term *anxiety* is not an apt word to use in this context. Most preservice elementary school teachers suffering from high levels of mathematics anxiety do not have symptoms synonymous with other cases of high anxiety (panic attacks, increased heart rate, etc.). Other terms such as *numerical avoidance* might be a more accurate description in some cases, but in the context of this research and in the context of the large collection of prior research of preservice elementary school teachers, the term mathematics anxiety will be used.

The occurrence of mathematics anxiety and its influence on preservice elementary school teachers has not gone unnoticed by educational researchers and teacher educators. Efforts have been made to help preservice elementary school teachers overcome their mathematics anxiety. For instance, the use of a mathematics methods course has been shown to reduce the levels of mathematics anxiety in preservice elementary school teachers (Gresham, 2007; Harper & Daane, 1998, Vinson, 2001). Enrollment in a mathematics methods course shows initial improvement, however little research has been done looking at the long-term benefits of this intervention. Gresham (2017) provides some of the only insight into the long-term effects a mathematics methods course has on mathematics anxiety. Gresham's study showed that mathematics anxiety reappeared or never left in-service elementary school teachers five years after their methods course as a preservice teacher. Gresham attributes these results to poor instructional quality of the methods course or an inadequate method of measuring mathematics anxiety levels in preservice and in-service elementary school teachers.

A common instrument used to measure mathematics anxiety is the Revised Mathematics Anxiety Rating Scale (RMARS) (Alexander & Martray, 1989) which is a variation of the Mathematics Anxiety Rating Scale (MARS) developed by Richardson and Suinn (1972). Questions on the RMARS ask respondents to rate, on a scale of one to five, how much a given situation frightens them. While the RMARS may be an effective measure of mathematics anxiety, the situations used in the scale portray the individual in the position of a student of mathematics not as a teacher. For example, situations include "picking up a math textbook to begin working on a homework assignment" or "being given a pop quiz in a math class." While this context is appropriate for many situations, the questions do not accurately represent the context in which a preservice elementary school teacher would engage with mathematics in their

future teaching career. When the goal is to identify and/or eliminate mathematics anxiety in preservice and in-service elementary school teachers and improve their teaching, the instruments being used should be an accurate representation of the experiences and context of teaching. The RMARS may identify a teacher as having high mathematics anxiety, but in the context of teaching mathematics the teacher may have no discomfort at all. This lack of anxiety could exist because the mathematics that is being taught at the elementary level is at a level that the preservice elementary school teacher is comfortable with or because the preservice elementary school teacher is not in the position of a student being assessed, instead they are in the position of the teacher who is in control of the assessment. Conversely, a preservice elementary school teacher may show little or no mathematics anxiety when in the context of being a student, but when placed in the context of teaching mathematics they may become anxious due to pressures associated with teaching (e.g. classroom management, using mathematical manipulatives they are not familiar with, or providing differentiated mathematics instruction). To help envision this scenario, consider a preservice elementary school teacher that is comfortable with the way "they do mathematics" but struggles with teaching concepts that are new to them, or the preservice elementary school teacher who struggles explaining their personal mathematical problem-solving methods to students. A preservice elementary school teacher like this would struggle and potentially be anxious to teach mathematics but would have low mathematics anxiety as measured by the RMARS and therefore go unidentified as needing support. This research could lead to better methods of identifying the teachers that need this support and help get them the appropriate help and instruction they need to improve their teaching practice.

## 1.5 Mathematics Teacher Efficacy

Mathematics self-efficacy is "a situational or problem-specific assessment of an individual's confidence in his or her ability to successfully perform or accomplish a particular mathematical task or problem" (Hackett & Betz, 1989, p. 262). While there is research looking at mathematics self-efficacy and its impact on preservice elementary school teachers (Briley, 2012; Unlu & Ertekin, 2013; Zuya, Kwalat, & Attah, 2016), the majority of research focused on preservice elementary school teachers looks specifically at mathematics teacher efficacy—an individual's belief in his or her ability to teach mathematics effectively. When studying preservice and in-service elementary school teachers, researchers extended mathematics self-efficacy to the more context specific mathematics teacher efficacy (Gresham, 2008; Gresham, 2017, Pyper, 2009; Swars, Daane, & Giesen, 2006). This extension led to meaningful research in terms of mathematics education, but a similar contextual leap from researching mathematics anxiety in preservice teachers to mathematics *teaching* anxiety has not yet been fully realized.

A negative correlation has been shown between mathematics teacher efficacy and mathematics anxiety (Bursal & Paznokas, 2006; Gresham, 2008; Swars, Daane, & Giesen, 2006) and with mathematics teaching anxiety (Peker & Ertekin, 2011). A preservice elementary school teacher with high levels of mathematics teacher efficacy would have confidence in their ability to impact their students, control their classroom environment, and manage potential obstacles that may arise when teaching mathematics. This belief in their ability to teach mathematics effectively helps to reduce feelings of anxiety surrounding teaching mathematics as the preservice elementary school teacher is confident that they will not succumb to struggles and challenges. Conversely, a preservice elementary school teacher with low levels of mathematics teacher efficacy does not believe they can overcome future struggles. This could lead the

preservice elementary school teacher to have increased levels of negative self-talk and fear of failure (Bandura, 1988).

Brown, Westenskow, and Moyer-Packenham (2011) and Adeyemi (2015) have argued against the assumption that all mathematically anxious preservice elementary school teachers have low levels of mathematics teacher efficacy. Both pieces of research have shown that there are examples of preservice elementary school teachers with high levels of mathematics anxiety but low levels of mathematics teaching anxiety and mathematics teacher efficacy. The researchers call for future research to be done to examine the experiences of preservice elementary school teachers and their experiences with mathematics anxiety and mathematics teacher efficacy.

## 1.6 Mathematics Teaching Anxiety

Differentiating mathematics anxiety from mathematics teaching anxiety and accurately measuring these levels in preservice and in-service elementary school teachers is a relatively new endeavor. Efforts have been made to examine the relationship between mathematics anxiety and mathematics teaching anxiety in preservice and in-service elementary school teachers (Adeyemi, 2015; Brown, Westenskow, & Moyer-Packenham, 2011; Haciomeroglu, 2014; Peker & Ertekin, 2011; Unlu, Ertekin, & Dilmac, 2017) with promising results. Specifically, Peker and Ertekin (2011) and Haciomeroglu (2014) found a positive relationship between mathematics anxiety and mathematics teaching anxiety in preservice elementary school teachers and encouraged further research to be undertaken on the relationship between the two constructs.

Although mathematics anxiety and mathematics teaching anxiety are positively correlated, a need for distinction between the two concepts is needed. Brown, Westenskow, and Moyer-Packenham (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). Furthermore, Adeyemi (2015) found that out of 111 in-service elementary school teachers, 46 reported having mathematics anxiety and no mathematics teaching anxiety. Both of these are strong examples of the need to differentiate the two measurements. Mathematics teaching anxiety is a new and promising field of research and a greater understanding of this construct could lead to improved preservice and in-service elementary school teacher experiences when teaching mathematics.

## 1.7 Overview of the Study

This dissertation will be organized into the following chapters: Chapter Two – Literature Review, Chapter Three – Methodology, Chapter Four – Results, Chapter Five – Portraits, and finally Chapter Six – Discussion. Chapter Two provides information on the history and current understanding of mathematics anxiety, mathematics teacher efficacy, and mathematics teacher efficacy. Chapter Three details the data collection and data analysis process of this research, including information on the questionnaire and interview protocol. Chapter Four provides the results of the quantitative and qualitative data analyses. Chapter Five uses portraiture as a method to present the findings. Finally, Chapter Six provides an interpretation of both the quantitative and qualitative using a mixed methods framework.

# Chapter Two – Literature Review

This study involves the three constructs: mathematics anxiety, mathematics teacher efficacy, and mathematics teaching anxiety. Each of these constructs have their own body of literature and research involving preservice elementary school teachers. These bodies of research overlap and often are examined in unison. Specifically, mathematics anxiety and mathematics teacher efficacy are commonly measured and discussed simultaneously. This literature review is presented with a section for each construct individually followed by a description how these constructs interact with each other.

## 2.1 Mathematics Anxiety

Mathematics anxiety was first described as "number anxiety" by Dreger and Aiken (1957) and defined as "a presence of a syndrome of emotional reactions to arithmetic and mathematics" (p. 344). Since then, mathematics anxiety has become a well-researched field and our understanding of mathematics anxiety has evolved. Richardson and Suinn (1972), creators of the Mathematics Anxiety Rating Scale, described mathematics anxiety as "feelings of tension or anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Similarly, over 25 years later Tobias (1998) described mathematics anxiety simply as a feeling of uncertainty when working with numbers. Burns (1998) went on to further describe mathematics anxiety as a state of discomfort that happens as a response to a situation that involves mathematical tasks that are perceived to be a threat to self-esteem. These definitions describe mathematics anxiety as a feeling of tension and difficulty that arises when a mathematical task is required.

It has been shown that mathematics anxiety plays a large role on mathematical performance (Miller & Bichsel, 2004; Baloğlu & Koçak, 2006), with varying explanations as to

why this is the case. One explanation as to why mathematics anxiety affects mathematics performance is based on mathematics avoidance (Ashcraft, 2002). Ashcraft argued that individuals who dislike mathematics avoid engaging with the subject. This lack of engagement causes future problems with mathematics leading to increased mathematics anxiety creating a negative spiral of mathematics anxiety. For preservice and in-service teachers with mathematics anxiety, avoiding mathematics is not a sustainable option. In Ontario, elementary school teachers are asked to provide 300 minutes of instructional minutes per five-day class cycle—preferably in daily blocks of 60 minutes with a minimum of 40 minutes per block (Ontario Ministry of Education, 2016). Some teachers with mathematics anxiety continue to avoid mathematics at the detriment of their students learning (Zakaria, Zain, Ahmad, & Erlina, 2012) while others are forced to confront their mathematics anxiety.

A second explanation as to how mathematics anxiety impacts mathematics achievement focuses on the stress mathematics anxiety puts on working memory (Ashcraft, Kirk, & Hopko, 1998). Working memory is vital to performing arithmetic operations. When an individual becomes anxious, they are likely to have intrusive thoughts that may overload their working memory capacity. With lower working memory capacity mathematical tasks become increasingly challenging in turn leading to increased mathematics anxiety. This again creates a negative spiral of mathematics anxiety. For preservice or in-service teachers with mathematics anxiety, teaching mathematics can cause a flow of negative thoughts that overwhelms their working memory. This overflow of negative thoughts about mathematics and the teacher's mathematical performance leads to a decrease in cognitive ability and mathematics teaching quality.

Mathematics anxiety is a multifaceted construct. For example, test anxiety has been shown to be linked to mathematics anxiety (Ashcraft, Kirk, & Hopko, 1998; Hembree, 1990) with a correlation as large as 0.5. Additionally, Hembree (1990) found a correlation of 0.35 between mathematics anxiety and general anxiety. However, this does not mean that mathematics anxiety can be fully described as just a combination of test anxiety and general anxiety (Hembree, 1990). There are potentially many different subcomponents contributing to the larger concept of mathematics anxiety. For instance, the Revised Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972), which is used in this study to measure mathematics anxiety, has three subscales: mathematics test anxiety (the feeling of anxiety associated with having to take a mathematics test or examination), numerical task anxiety (the feeling of anxiety associated with numerical manipulation such as addition or multiplication), and mathematics course anxiety (the feeling of anxiety associated with taking a course on mathematics).

The prevalence of mathematics anxiety in our society has inevitably spurred discussion around potential treatments. Dowker, Sarkar, and Looi (2016) argued that parents and teachers are the first step towards preventing and treating mathematics anxiety in students. By modelling positive attitudes towards mathematics, parents and teachers can positively influence student's perceptions. Unfortunately, the converse holds true as well—parents and teachers modelling negative attitudes towards mathematics can negatively influence student's perceptions. With estimates of 17% or more of the population having high levels of mathematics anxiety (Ashcraft & Moore, 2009), focused effort should be put into positively shaping the view of mathematics for the entire family as well as the student.

Improving mathematical content knowledge has also been used in attempts to reduce mathematics anxiety. Supekar, Iuculano, Chen, and Menon (2015) examined the effect that an

eight-week tutoring program had on the mathematic anxiety levels of children aged seven to nine. Supekar and colleagues found a significant reduction in mathematics anxiety, showing that relatively short but intense tutoring sessions can reduce mathematics anxiety.

Other methods for potential treatments for mathematics anxiety include helping people to reappraise the consequences of their mathematics anxiety (Jamieson, Mendes, Blackstock, & Schmader, 2010), writing down the negative feelings and worries associated with mathematics anxiety (Ramirez & Beilock, 2011), and even non-invasive brain stimulation using mild electrical current applied to the scalp in order to upregulate and downregulate neural activity (Sarkar, Dowker, Cohen Kadosh, 2014).

**2.1.1 Mathematics anxiety in preservice teachers.** Preservice teachers have been identified as an at-risk group for mathematics anxiety (Bursal & Paznokas, 2006; Gresham, 2009; Vinson, 2001). A higher percentage of preservice teachers reported experiencing mathematics anxiety compared to other undergraduate university students (Bursal & Paznokas, 2006; Gresham, 2004; Harper & Daane, 1998; Hembree, 1990). This is a consistent trend with evidence from as early as the 1980's when Kelly & Tomhave (1985) tested a group of college freshman using the Mathematics Anxiety Rating Scale (MARS). Kelly and Tomhave found that "elementary education majors scored higher on the MARS than any of the other groups except those in a math anxious workshop (p. 52). Additionally, Frank (1990) found that preservice teachers held beliefs similar to those of people enrolled in math anxiety clinics.

Evidence has shown that high levels of mathematics anxiety in preservice teachers can lead to poor mathematical performance (Gresham, 2009) and increased levels of mathematics anxiety (Vinson, 2001) in their future students. Preservice teachers with high levels of mathematics anxiety are more likely to use traditional teaching methods such as lecturing,

devoting more time to seatwork, and are likely to avoid using engaging and unstructured teaching methods such as implementing manipulatives in their lessons and using open-ended questions (Bursal & Paznokas, 2006; Gresham, 2004; Vinson, 2001). This reliance on lecturing and seatwork may lead to poor student experiences, performance, and a future of mathematics anxiety.

Efforts are made in teacher education programs to reduce mathematics anxiety in preservice elementary school teachers. Gresham (2007) completed a study involving 246 preservice elementary school teachers and their mathematics anxiety before and after participating in a mathematics methods course. Gresham found a statistically significant reduction in mathematics anxiety in the preservice elementary school teachers after the methods course. Similarly, using a pretest posttest analysis of mathematics anxiety in 72 preservice elementary school teachers, Sloan (2010) found a significant decrease in mathematics anxiety levels after a mathematics methods course. Unfortunately, while there is an initial reduction in the levels of mathematics anxiety there is evidence to suggest that these methods courses are not a long-term solution to the problem. Gresham (2017) surveyed and interviewed ten in-service teachers who were a part of a study five years prior that involved mathematics anxiety levels of preservice teachers before and after a methods course. Gresham found that although there was an initial reduction in mathematics anxiety, all ten of the in-service teachers had their mathematics anxiety return during their future teaching. These results imply that mathematics anxiety may not be easily reduced, and better measurements or ongoing support may be necessary for our preservice teachers.

**2.1.2 Measures for mathematics anxiety.** Mathematics anxiety is often measured using questionnaires and rating scales. Some of the most well-known instruments for measuring

mathematics anxiety include the Fennema-Sherman Mathematics Attitude Scale (Fennema & Sherman, 1976) and the Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972). The Fennema-Sherman Mathematics Attitude Scale contains nine scales comprised of measures for constructs such as the attitude toward success in mathematics scale (measuring how students anticipate the positive or negative consequences of success in mathematics), the mathematics as a male domain scale (measuring to what extent students view mathematics as a male, female, or neutral field), and the mother/father scale (measuring how the student perceives their mother and/or father's level of support, encouragement, and confidence in the student's ability). This instrument is commonly used when a researcher wants to focus on gaining insight into sex-related differences in mathematics anxiety and does not fully fit the purpose of this research.

The Mathematics Anxiety Rating Scale (MARS) (Richardson & Suinn, 1972) is a 98-item scale comprised of real-world situations where an individual is asked to rank their level of anxiety on a scale of one to five. This scale has been found to be a reliable measure of mathematics of anxiety (Levitt & Hutton, 1984) and fits appropriately with the aims of this study. Unfortunately, as a 98-item scale, the MARS runs the risk of losing participants based on the length. Thankfully, The Revised Mathematics Anxiety Rating Scale (RMARS) was developed (Alexander & Martray, 1989) to capture the levels of mathematics anxiety in an individual with a much smaller, efficient, and more manageable 25-item scale. RMARS is a commonly used alternative to the MARS because of its shortened length and has shown to be both a reliable and valid instrument (Alexander & Martray, 1989).

There are a variety of other methods of measuring mathematics anxiety that are promising but inappropriate or unrealistic for this study. When measuring children, some questionnaires such as the Mathematics Attitude and Anxiety Questionnaire (Thomas & Dowker,

2000) and the Children's Attitude to Math Scale (Jameson, 2013) use a pictorial rating scale to better suit children. While this is a valid measure of mathematics anxiety, it is not appropriate for preservice teachers who are expected to be 20 years of age or older. Researchers such as Mattarella-Micke, Mateo, Kozak, Foster, and Beilock (2011) take a vastly different approach to measuring mathematics anxiety by measuring cortisol secretion levels before and after a participant is given a mathematic problem. While this measure may be valid and reliable, it is neither feasible nor appropriate for this study. The resources and expertise necessary for this measurement of mathematics anxiety is not within the scope of this research.

## 2.2 Mathematics Teacher Efficacy

Mathematics teacher efficacy originated in Bandura's (1986) self-efficacy and social cognitive theory. Bandura (1997) describes self-efficacy as the "beliefs in one's capabilities to organize and execute the course of action required to produce given attainments" (p. 3). Bandura described two components of self-efficacy: outcome expectancies (the belief that a behaviour will result in the intended consequences) and efficacy expectations (the belief that the individual has the capabilities to perform the behaviour). These two components together account for an individual's level of self-efficacy.

Bandura (1977) explained that efficacy beliefs were dependent on the specific context. For example, an individual's belief in their ability to pass a mathematics test would be measured by that individual's level of mathematics efficacy whereas an individual's belief in their ability to pass a science test would be measured by that individual's level of science efficacy. The importance of context specificity is vital for this dissertation. Learning subject matter is different than teaching subject matter and calls for a different set of skills, practices, and beliefs. When

discussing in-service and preservice teachers it is important to distinguish teacher efficacy from student self-efficacy as these constructs depict very different things.

Berman, McLaughlin, Bass, Pauly, and Zellman (1977) describe teacher efficacy as the "extent to which the teacher believes he or she has the capacity to affect student performance" (p. 137). A teacher's efficacy has been associated with various student outcomes such as motivation (Midgley, Feldlaufer, & Eccles, 1989), achievement (Henson, 2001; Moore & Esselman, 1992; Ross, 1992) and students' own levels of self-efficacy (Anderson, Greene, & Loewen, 1988). Teachers with a high sense of teacher efficacy put forward more effort and perseverance compared to teachers with low efficacy when faced with a challenge during the teaching process (Gavora, 2010). Swars, Daane, and Giesen (2006) found that teachers with low teacher efficacy use poor instructional strategies and show little willingness to embrace innovation in their classroom. Additionally, Czernaik (1990) found that highly efficacious teachers were student-centered in their teaching strategies and used difficult yet effective teaching strategies, such as inquiry-based instruction. Tschannen-Moran and Woolfolk Hoy (2001) describe teacher efficacy as being both classroom context specific and subject-matter specific. Therefore, one can further extend teacher efficacy to mathematics teacher efficacy by specifying the subject-matter to mathematics and context to a mathematics classroom.

If we specify the context of teaching in a mathematics classroom, we can adapt the definition given by Berman, McLaughlin, Bass, Pauly, and Zellman (1977) to *mathematics* teacher efficacy being "the extent to which a *mathematics* teacher believes he or she has the capacity to affect student *mathematical* performance". Kahle (2008) described mathematics teacher efficacy as being about how teachers positively influence students to foster success in mathematics and reduce anxiety and negative beliefs about mathematics. In a study involving

144 preservice elementary school teachers, mathematics teacher efficacy was shown to be positive correlated to mathematics efficacy (Unlu & Ertekin, 2013). Additionally, mathematics teacher efficacy was negatively correlated with mathematics teaching anxiety (Gresham, 2008; Unlu, Ertekin, & Dimac, 2017) and negatively correlated with mathematics anxiety (Peker, 2016).

**2.2.1 Mathematics teacher efficacy in preservice teachers.** It is important to help preservice teachers establish a high sense of mathematics teacher efficacy because, as Hoy (2000) indicated, "once efficacy beliefs are established, they appear to be somewhat resistant to change" (p. 392). Because of this, increased efforts are made to impact preservice teachers' mathematics teacher efficacy early before they begin teaching. Several studies have indicated a statistically significant increase in mathematics teacher efficacy after completing one methods course or a sequence of methods courses (Charalambous, Philippou, & Kyriakides, 2008; Swars et al., 2007; Utley, Moseley, & Bryant, 2005) as well as upon completion of a mathematics content course (Alsup, 2004).

Swars, Daane, and Giesen (2006) followed 28 elementary school preservice teachers who had just completed a mathematics methods course. Of the 28 preservice elementary school teachers, four were interviewed to gather further information about their experiences. The researchers found that the preservice teachers who struggled with mathematics believed that their struggles helped them build a sense of understanding and compassion that made them confident in their ability to teach mathematics to their future students. The preservice teachers who did not struggle with mathematics reported a higher sense of efficacy based on their ability to rely on their mathematics content knowledge to teach. This study showed that the level of mathematics teacher efficacy in preservice teachers can come from a variety of sources that is specific to the

individual with some relying on personal experiences, some relying on pedagogical knowledge, and others relying on content knowledge.

Mathematics teacher efficacy was also found to be associated with teachers' past experiences as learners of mathematics (Brown, 2012; Swars, 2005). To identify the factors that contribute to the development of preservice teachers' efficacy beliefs, Charalambous, Philippou, and Kyriakides (2008) administered the Teachers' Sense of Efficacy Scale to 89 preservice elementary school teachers and held informal interviews with eight of those preservice teachers. Each interviewee was interviewed three times, at the onset, half-way through, and at the end of a mathematics methods course with varying questions related to the preservice teachers' relationship and beliefs with mathematics and teaching mathematics. The researchers found that the preservice elementary school teachers attributed their efficacy beliefs to a mix of their experiences as learners of mathematics, their actual experiences in teaching mathematics, and feedback received from mentors (e.g., methods course instructors, associate teachers, etc.) This research is important because it shows that preservice elementary school teachers' levels of mathematics teacher efficacy is being formed while they are still students in their earlier elementary and secondary mathematics classrooms. If a future elementary school teacher has a poor experience in their mathematics classroom this will negatively impact their future beliefs. This research speaks again to the cyclical nature of mathematics teacher efficacy and mathematics anxiety.

**2.2.2 Measures for mathematics teacher efficacy.** Throughout the literature, two instruments are commonly used: The Mathematics Teacher Efficacy Beliefs Instrument (Enochs, Smith, & Huinker, 2000) or a modified version of the Teacher's Sense of Efficacy Scale (Tschannen-Moran & Woolfolk Hoy, 2001). Prior to the development of the Teachers'

Sense of Efficacy Scale a common measure for teacher efficacy was the Gibson and Dembo Teacher Efficacy Scale (Gibson & Dembo, 1984). The Gibson and Dembo Teacher Efficacy Scale was a two-dimensional instrument. Gibson and Dembo claimed these two dimensions aligned well with Bandura's notion of outcome and efficacy expectations. Upon further investigation of the instrument, Woolfolk and Hoy (1990) suggested that the match of the instrument's two dimensions to Bandura's notion of outcome and efficacy expectations was not perfect. Woolfolk and Hoy also found that the factor structure of the Gibson and Dembo Teacher Efficacy Scale could have been influenced by the item orientation (items for the first factor were primarily positively orientated whereas items for the second factor were primarily negatively orientated). With these critiques and the eventual introduction of The Mathematics Teacher Efficacy Beliefs Instrument and Teacher's Sense of Efficacy Scale, the Gibson and Dembo Teacher Efficacy Scale fell out of favour.

The Mathematics Teacher Efficacy Beliefs Instrument includes twenty-one items and two subscales. These two subscales are the personal mathematics teacher efficacy subscale (measuring a teacher's belief in their ability to be an effective math teacher) and the mathematics teaching outcome expectancy subscale (measuring a teacher's belief that effective mathematics teaching can bring about positive change in the student regardless of external factors). Enochs et al. (2000) have shown that the Mathematics Teacher Efficacy Beliefs Instrument is both a reliable and valid measure of mathematics teacher efficacy.

Tschannen-Moran and Woolfolk Hoy (2001) developed the Teachers' Sense of Efficacy Scale, which looks at teacher efficacy in a general context, not a mathematics teaching context. The short form of this scale is comprised of 12 items and through factor analysis Tshcannen-Moran and Woolfolk Hoy found three underlying structures of their scale: efficacy for

instructional strategies, efficacy for classroom management, and efficacy for student engagement. While the Teachers' Sense of Efficacy Scale is used to measure teacher efficacy in a general capacity, a small modification of the questions to change the context to a mathematics classroom with mathematics instruction allows for a measure of mathematics teacher efficacy.

When developing the instrument, three studies were used to refine and examine the Teachers' Sense of Efficacy Scale. The first two studies were used to refine the scale and reduce the number of items from 52 items to 32 items using the first study and then from 32 items to 18 items using the second study. In the third study participants responded to the Teachers' Sense of Efficacy Scale and two other measures of teacher efficacy: The Rand Items (Armor et al., 1976) and the Hoy and Woolfolk (1993) 10-item adaptation of the Gibson and Dembo Teacher Efficacy Scale. The scores for the short form Teachers' Sense of Efficacy Scale were found to be positively correlated to both of the Rand Items ($r$ = .18, and $r$ = .52, $p \leq 0.01$) as well as with general teacher efficacy ($r$ = .16, $p < 0.01$) and personal teacher efficacy ($r$ = .61, $p < 0.01$) from the 10-item adaptation of the Gibson and Dembo Teacher Efficacy Scale. The reliability of the subscales for the short form Teachers' Sense of Efficacy Scale are $r$ = .86 for instructional strategies, $r$ = .86 for classroom management, and $r$ = .81 for student engagement. These results indicate that the short form Teachers' Sense of Efficacy Scale could be considered valid.

Overall, both the Teachers' Sense of Efficacy Scale and The Mathematics Teacher Efficacy Beliefs Instrument are valid and reliable measures of mathematics teacher efficacy, but The Teachers' Sense of Efficacy Scale developed by Tschannen-Moran and Woolfolk Hoy was ultimately chosen for this study. There were multiple reasons for this choice. First, Tschannen-Moran and Woolfolk Hoy's Teachers' Sense of Efficacy Scale has the three subscales (efficacy for instructional strategies, efficacy for student engagement, and efficacy for classroom

management) whereas Enoch, Smith, and Huinker's Mathematics Teacher Efficacy Beliefs Instrument has the two subscales (personal mathematics teacher efficacy and mathematics teaching outcome expectancy). The number of subscales was not the determining factor here, but the contents of these subscales influenced the choice. The subscales of the Teachers' Sense of Efficacy Scale provided more descriptive measures of the preservice teacher's instruction and classroom practices (their belief in their teaching practices, ability to manage a classroom, and keep their students engages) whereas the subscales of the Mathematics Teacher Efficacy Beliefs Instrument measure constructs closer to personal mathematics efficacy and teacher efficacy. This research is focused on the context of teaching in the classroom and the subscales of the Teachers' Sense of Efficacy scale better capture this.

Second, the Teachers' Sense of Efficacy Scale was found to have higher reliability (0.90 for the Teachers' Sense of Efficacy Scale versus 0.88 for the Mathematics Teaching Efficacy Beliefs Instrument) and validity (the Teachers' Sense of Efficacy Scale was found to have high validity when compared to the Rand Items and Gibson and Dembo's Teacher Efficacy Scale—two other measures for teacher efficacy (Tschannen-Moran & Woolfolk Hoy, 2001) whereas the Mathematics Teaching Efficacy Beliefs Instrument was found to have a "reasonably good model fit" (Enochs, Smith, & Huinker, 2000) when tested for validity. Finally, the Teachers' Sense of Efficacy Scale was recommended by colleagues with previous experience with the instrument. I believe that an argument could be made for the use of either of the two instruments, but The Teachers' Sense of Efficacy Scale better aligns with the vision of this dissertation and the benefit of having colleagues who have experience with scale is valuable.

## 2.3 Mathematics Teaching Anxiety

Unlike the relatively well-researched mathematics anxiety and mathematics teacher efficacy, mathematics teaching anxiety is a newer construct and not much is really known about it. Mathematics teaching anxiety is defined as an individual's feelings of tension and fear that takes place during the teaching of mathematical concepts (Levine, 1993). Unlike mathematics anxiety which describes a feeling of tension in "a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551), mathematics teaching anxiety is the feeling of fear or anxiety experienced by teachers specifically when they are in the context of teaching mathematics. Brown, Westenskow, and Moyer-Packenham (2011) described the distinction noting:

> Mathematics anxiety is more internally focused and reflects how the individual views their own ability to interact with the mathematics; on the other hand, mathematics teaching anxiety is more externally focused and reflects how the individual views their ability to engage children in an interaction with the mathematics. (p. 2)

This distinction between mathematics anxiety and mathematics teaching anxiety appears to be small, but the implications for assuming the difference is insignificant may be very detrimental to preservice teachers and their future students.

**2.3.1 Mathematics teaching anxiety in preservice teachers.** 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.

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 in-service teachers teaching mathematics in the classroom, researchers use instruments focused on measuring mathematics anxiety whereas mathematics teaching anxiety appears to be closer aligned with their research questions. An initial effort to distinguish mathematics teaching anxiety from mathematics anxiety was done by Brown, Westenskow, and Moyer-Packenham (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. Brown, Westenskow and Moyer-Packenham make the argument that different

strategies should be considered within mathematics methods courses to better benefit preservice elementary school teachers with different levels of mathematics anxiety and mathematics teaching anxiety.

Following their previous work, Brown, Westenskow, and Moyer-Packenham (2012) analyzed 55 preservice elementary school teachers' reflections to specifically look for common themes of anxiety-provoking or anxiety-reducing events experienced during their placements. The reflections took place after a five-week teaching practicum experience where preservice elementary school teachers were required to plan and teach a minimum of three mathematics lessons and were voluntarily submitted for the purposes of this research. Each reflection was guided by the following questions: (a) How confident did you feel while you were teaching mathematics lessons? (b) Were you more comfortable teaching the mathematics lessons or the lessons in one of the other subjects? Please explain WHY? (c) Describe your best moment when teaching a mathematics lesson. What happened? (d) Describe your worst moment when teaching a mathematics lesson. What happened? (e) Explain how your own personal experiences with mathematics influenced your mathematics teaching during the practicum experience.

Using these data, Brown, Westenskow and Moyer-Packenham found three major themes that related to an increase or a decrease in the preservice teachers' level of mathematics teaching anxiety: adapting to established teaching structures (anxiety over the curriculum, supervision structure, and resources), preparing for the mathematics classroom (a reduction in anxiety by observing other teachers, reflecting, and practicing), and recognizing personal attributes for mathematics teaching (prior experiences leading to increased or decreased mathematics anxiety). This research allowed for a better look at the reasons behind mathematics teaching anxiety and better ways that teacher educators can prepare their students for success. For example, they

incorporated internal-external locus of control (Rotter, 1966) in their interpretation of the results. They discussed the linear progression of their three themes moving from the most external locus of control (adapting to established teaching structures) to a more internal locus of control (preparing for the mathematics classroom) to the most internal locus of control (personal attributes for mathematics teaching). They found that if an experience had an external locus of control then it raised the preservice teacher's mathematics teaching anxiety and if an experience came from a more internal locus of control than it had a reduction in the preservice teacher's level of mathematics teaching anxiety. This suggests that providing preservice teachers with better mathematics teaching tools and knowledge to increase their ability to control their classroom environment may be a method for reducing mathematics teaching anxiety compared to simply increasing mathematics content knowledge. For example, providing guidance on how to properly teach mathematics using common manipulatives found in elementary classrooms will help provide preservice teachers with more internal locus of control over the various classroom environments they will face.

The causes for mathematics teaching anxiety are not yet fully understood. While the causes of mathematics anxiety have been explored in past research (Furner & Berman, 2003; Maloney & Beilock, 2012; Uusimaki & Nason, 2004), as noted previously, there is rarely a distinction between mathematics anxiety and mathematics teaching anxiety. In a study involving 316 preservice teachers, Peker and Ertekin (2011) talk briefly about the potential causes of mathematics teaching anxiety. They claim that the data they collected eluded to a distinction between the anxieties caused by a lack of content knowledge and the anxiety caused by methodological knowledge (having to teach mathematics in a style they were not comfortable with), but no exact results were discussed.

### 2.3.2 Measures for mathematics teaching anxiety.

With mathematics teaching anxiety being a relatively new area of research, very few instruments have been developed to measure the construct. The most commonly used instrument is the Mathematics Teaching Anxiety Scale developed by Peker (2006). The Mathematics Teaching Anxiety Scale is comprised of twenty-three five-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, 2015). Adeyemi reported confusion and social discrepancies between the English and Turkish translations that Adeyemi claims could have resulted in less than optimal results. For example, when translating the instrument, the translators debated between choices of words such as using “love” or “like” as well as using “believe” or “think”. In casual conversation these distinctions may seem trivial, but for an instrument measuring teacher beliefs, these choices can have considerable impact. Adeyemi acknowledged difficulty in establishing proper and rigorous translation techniques. Adeyemi used two self-reported bilingual translators (not properly accredited in being able to translate between Turkish and English), a professor in mathematics education and a post-doctoral student in engineering, to independently translate the questionnaire. Adeyemi found that there were discrepancies in the exact terminology used in the questions and needed to change specific words such as “love” and “believe” to words that correspond better to everyday language. Adeyemi also pilot-tested the translated survey with 10 individuals including teachers, students, and a librarian to help better refine the translation. 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.

To avoid the above translation issue, the Teaching Anxiety Scale (Parsons, 1973) was explored as another viable option for measuring mathematics teaching anxiety as it was developed and implemented with English speaking participants in America. The Teaching Anxiety Scale is a 29-item scale comprised of Likert scale items developed to measure the levels of teaching anxiety in preservice teachers. After developing the Teaching Anxiety Scale and looking at the individual items, Parsons (1973) hypothesized that there would be three internal components to teaching anxiety. These internal components were anxiety about being evaluated, anxiety about maintaining discipline, and anxiety about being able to teach effectively. When the internal consistency was tested it was revealed that the alpha coefficients for internal consistence ranged from 0.87–0.93, "suggesting that teaching anxiety, as measured by the Teaching Anxiety Scale, is a unitary variable" (Parsons, p. 16). Although Parson's Teaching Anxiety Scale was developed over forty years ago, it is still being used in current studies with preservice teachers and found to be univariable (Bilali, 2014; Cheung & Hui, 2011; Al-Mehrzi et al., 2011).

Similar to the modification used for the Teachers' Sense of Efficacy Scale by Tschannen-Moran and Woolfolk-Hoy (2001), the questions of the Teaching Anxiety Scale can be used to measure mathematics teaching anxiety by modifying the questions to be situated in a mathematical context. The Teaching Anxiety Scale has not been used to measure mathematics teaching anxiety but using this instrument would avoid any potential issues of translation error from Turkish to English.

## 2.4 The Relationships Between the Constructs

Mathematics anxiety, mathematics teacher efficacy, and to a smaller degree, mathematics teaching anxiety, each have their own foundation of research involving preservice elementary school teachers. The teaching of mathematics inherently causes interaction between the three constructs. This section will give a brief description of the research surrounding how these constructs influence and interact with each other.

**2.4.1 Mathematics anxiety and mathematics teacher efficacy.** As described earlier, a teacher's belief in their teaching effectiveness contributes to their level of mathematics teacher efficacy. It seems reasonable that if a teacher is anxious to perform mathematical tasks then they would have a reduced belief in their ability to effectively teach mathematics. This section will examine the research performed with the assumption that mathematics anxiety is negatively associated with mathematics teacher efficacy.

Bursal and Paznokas (2006) studied 65 elementary preservice teachers enrolled in methods courses for elementary mathematics, science, and social studies. Bursal and Paznokas measured the preservice teachers' levels of mathematics anxiety, science teacher efficacy, and mathematics teacher efficacy using a questionnaire. The preservice teachers were separated into low, moderate, and high mathematics anxiety groups based on their responses from the questionnaire. An analysis of variance was run to look at the differences in the preservice teachers' levels of mathematics and science teacher efficacy based on their levels of mathematics anxiety. The results showed a negative correlation ($r$ = -.417) between the preservice elementary school teachers mathematics anxiety and mathematics teacher efficacy.

In a larger study, Gresham (2008) surveyed and interviewed 156 elementary preservice teachers and found similar results. Interestingly, Gresham notes that "the interviews indicated

that those preservice teachers with the highest levels of mathematics anxiety were somewhat optimistic about their skills and abilities to teach mathematics effectively" (p. 182). This finding suggests that although mathematics anxiety plays a critical role in mathematics teacher efficacy, there still seem to be other factors that contribute to a teacher's mathematical teacher efficacy. Other research has uncovered similar results. As discussed earlier, Swars, Daane, and Giesen (2006) surveyed and interviewed 28 elementary preservice teachers to find the relationship between mathematics anxiety and mathematics teacher efficacy. As expected, they found a moderate negative relationship between the two constructs. That is, the individuals became less mathematically anxious as their mathematics teacher efficacy rose. Of these 28, four preservice teachers were purposefully selected to be interviewed—the two who scored highest and the two who scored the lowest in terms of mathematics anxiety. Swars, Daane, and Giesen (2006) found that "all four of the preservice teachers, regardless of level of mathematics anxiety, indicated that they believed they could teach mathematics effectively" (p. 310).

**2.4.2 Mathematics teacher efficacy and mathematics teaching anxiety.** Bandura (1988) explicitly described the connection between self-efficacy and anxiety explaining that the perceived self-efficacy to control a potential problem or threat that arises in a situation plays a central role in anxiety arousal. Transitioning this into the context of teaching mathematics, could imply that if a teacher has a high sense of mathematical teacher efficacy then they believe they are capable of handling any problem or threat that may arise during a mathematics lesson. In turn, this would reduce an individual's feelings of mathematics teaching anxiety.

Ural (2014) found that, with 42 mathematics preservice teachers, efficacy beliefs about mathematics were negatively related to mathematics teaching anxiety; however, mathematics teacher efficacy was not measured. Peker (2016) administered a mathematics teaching anxiety

scale and self-efficacy belief towards mathematics teaching scale to 250 preservice elementary school teachers in Turkey. The purpose of this study was to investigate the relationship between the two constructs using a path analysis (a methodological technique similar to multiple regression which helps analyze the relationship between observed variables). Using the subscales of the two instruments, Peker was able to speak to specific subscales of mathematics teaching anxiety interacting with specific subscales of mathematics teacher efficacy based on the instruments used. Peker found that content knowledge (a subscale of the mathematics teaching anxiety instrument) negatively affected mathematics teacher efficacy, self-confidence (a subscale of the mathematics teaching anxiety instrument) had a negative effect on mathematics teacher efficacy, and knowledge (a subscale of the mathematics teaching anxiety instrument) had a negative effect on the teaching dimension of mathematics teacher efficacy.

**2.4.3 Mathematics anxiety and mathematics teaching anxiety.** It is easy to assume that an individual with high levels of mathematics anxiety would have high levels of mathematics teaching anxiety. Interestingly, the results of the literature surrounding the two constructs is undecided. The following section is a brief description of the ongoing discussion regarding the interaction of the two constructs.

One of the earliest studies looking at the relationship between mathematics anxiety and mathematics teaching anxiety was done by Peker and Ertekin (2011). The researchers surveyed 316 Turkish preservice teachers and reported their levels of mathematics anxiety and mathematics teaching anxiety. The results indicated a positive, moderate relationship between preservice teachers' mathematics teaching anxiety and mathematics anxiety. Additionally, Haciomeroglu (2014) surveyed 260 elementary preservice teachers in Turkey and found a significant positive relationship between mathematics anxiety and mathematics teaching anxiety.

That is, a teacher with high levels of mathematics anxiety is likely to also have high levels of mathematics teaching anxiety.

Interestingly, in the study referenced earlier by Brown, Westenskow, and Moyer-Packenham (2011), data from written reflections were used in addition to survey data to gain a deeper understanding of the interaction between mathematics teaching anxiety and mathematics anxiety. The researchers found that one-third of the 53 preservice teachers reported high mathematics anxiety but did not experience mathematics teaching anxiety. This result suggests that mathematics anxiety and mathematics teaching anxiety may not always be linked. The researchers go as far as to create a diagram containing quadrants labelled as; 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 fifty-three preservice teachers in them. This result shows that mathematics anxiety and mathematics teaching anxiety are not always linked and are experienced differently by each individual.

## 2.5 Conclusion

The purpose of this literature review was to describe the landscape of mathematics anxiety, mathematics teacher efficacy, and mathematics teaching anxiety. By reviewing this literature, it became apparent that mathematics teaching anxiety needs to be the focus of research going forward. Where the field stands as of now, mathematics anxiety has become the metric of focus when preservice teachers are discussed. The research presented above shows that there is not an accurate measure of what affects the teachers' sense of anxiety and efficacy in the sense of their classroom practice. I propose that a shift in focus from mathematics anxiety to

mathematics teaching anxiety would help better identify the struggle that our preservice teachers are going through and ultimately improve their practice and benefit their students.

The focus of this research was to pull apart and distinguish these three constructs from each other and determine how they impact preservice elementary school teachers' beliefs about and practices of teaching mathematics. The design of the study, questions asked, and instruments used have been shaped by the literature with the goal of uncovering and expanding on the feelings preservice teachers have when teaching mathematics.

# Chapter Three – Methodology

## 3.1 Rationale

With a background in mathematics, a quantitative analysis of the world is where I feel most comfortable. However, as I gained experience with educational research, I began to see aspects of the world that cannot be quantified. Although I am relatively new to qualitative research, the benefits are clear—the use of qualitative research can provide a deeper understanding of the lived experiences of an individual, which is something that is often missed by quantitative research. Being able to gain a deep understanding through qualitative research (for example, through interviews) paired with the benefits of using a large-scale analysis (ability to see patterns as well as use findings to make more generalizable statements about a larger population) through quantitative research (for example, through questionnaires) is why I employed a mixed methods approach methodology for this study.

Creswell and Plano Clark (2007) define mixed methods research as:

> A research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative and quantitative approaches in many phases in the research process. As a method, it focuses on collection, analyzing, and mixing both quantitative and qualitative data in a single or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone. (p. 5)

Many researchers argue for the use of mixed methods research over monomethod research based on the power of methodological triangulation (Greene, Caracelli, & Graham, 1989; Mertens & Hesse-Biber, 2012). The use of triangulation in mixed methods research is beneficial as it allows

a direct comparison of the results from the quantitative method to the results obtained from a qualitative method. This comparison can help obtain a more valid conclusion about the phenomenon being studied.

My drive to switch from studying mathematics to educational research was led by my ambition to answer the research questions described earlier. These questions are the focus of this research and as such they were the driving force and inspiration for the methodological decisions made. Specifically, the research question "what is the relationship between mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy?" drives the use of the large-scale questionnaire while the research question "how are the varying levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy experiences in elementary school preservice teachers in Ontario drives the use of interviews. This approach to conducting research falls in line with the philosophical viewpoint of *pragmatism*. Curry and Nunez-Smith (2014) describe pragmatism as:

> Pragmatism seeks to use whatever research methods are best suited to address a particular question, given the nature of what is being studied; as such, this orientation is practical and applied in nature. Pragmatism places value on both quantitative and qualitative methods (or some might say objective and subjective knowledge) and maintains that the methods are secondary to the research question. Simply put, we use whatever works. (p. xxii)

For Curry and Nunez-Smith, using the most effective and appropriate approach to answering the research questions is the main consideration when making methodological decisions.

Johnson and Onwuegbuzie (2004) assert that both qualitative and quantitative methods have their individual strengths and weaknesses. In some instances, a qualitative method would be

most appropriate, in others a quantitative method, but in many situations combining both methods would produce superior research outcomes. For this study both a questionnaire and interviews were utilized. The questionnaire was used to give an overarching look at the landscape of the constructs while the interviews allowed for a deeper look at how these constructs interact with each other and provided insight into the experiences of the preservice elementary school teachers. Morgan (2007), Patton (1990), and Tashakkori and Teddlie (2010) also stress the importance pragmatism puts on the research questions of a study and the use of a mixed methods approach to help understand the problems that are being researched.

As a worldview, pragmatism is a blend of constructivism and positivism. Constructivists claim that individuals construct their own reality, while positivists believe that there is a single reality that is observed. As Morgan (2007) describes: "in a pragmatic approach, there is no problem with asserting both that there is a single real world and that all individuals have their own unique interpretations of that world" (p. 72). As such, when collecting data, the researcher must work with the individual to interpret the meaning and context of a situation. This implies that it is impossible for the researcher to separate themselves from the research and be completely unbiased. I, as the researcher, view the world in a particular way and I carry my own biases. It is important that I, as the researcher, viewed myself as an instrument for data collection and declared my viewpoints for the reader.

## 3.2 Research Design

A modified version of an explanatory sequential mixed methods design (Creswell & Plano Clark, 2007) with three phases (Figure 1) was used for this research. The study consisted of a quantitative phase (questionnaire) followed by two qualitative phases (interviews) then

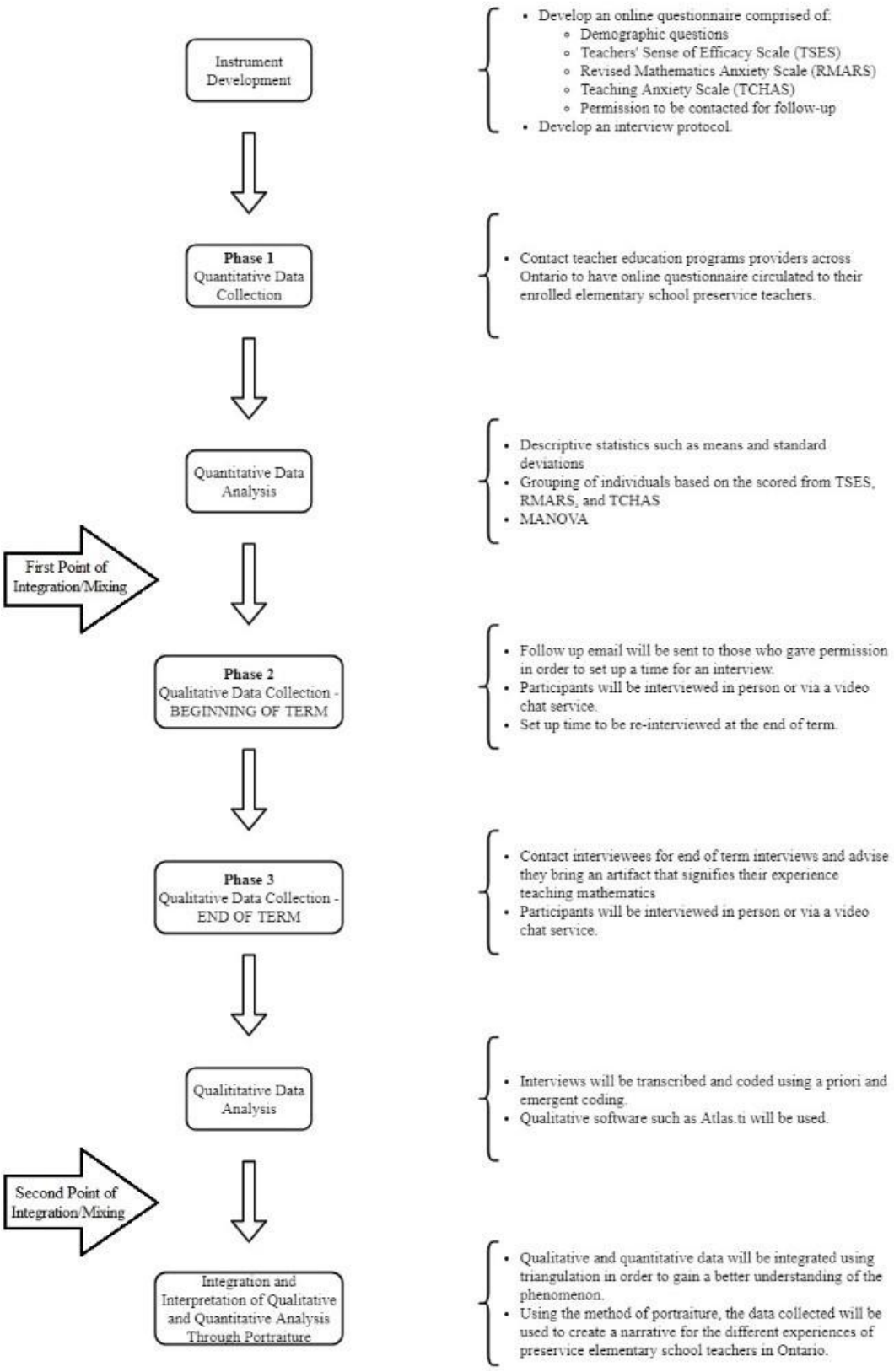


*Figure 1.* Diagram of three phase explanatory sequential mixed methods design.

analysis and integration. Typically, this design gives priority to the quantitative results, but as Creswell, Plano Clark, Gutmann, and Hanson (2003) claim:

> In an important variation of this design, the qualitative data collection and analysis is given the priority. In this case, the initial quantitative phase of the study may be used to characterize individuals along the certain traits of interest related to the research question. These quantitative results can then be used to guide the purposeful sampling of participants for a primarily qualitative study. (p. 178)

A brief description of the phases of the study will be given below to gain a better understanding of the design and how it fits this study.

**3.2.1 Phase one.** A questionnaire comprised of 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 & Woolfolk Hoy, 2001), and a question asking for permission to be contacted for a follow-up interview was sent to preservice elementary school teachers across Ontario. This was accomplished by contacting the appropriate individuals at each Faculty of Education across Ontario and asking for permission to distribute the questionnaire through a student email list. Additionally, help from personal contacts was sought through conferences and communities closely linked to mathematics teacher education (The Canadian Mathematics Education Study Group, The Canadian Society for the Study of Education, etc.). Leveraging these communities helped increase awareness of the study and raise response rates. As shown in Figure 1, the data gathered from the questionnaire were analyzed and used as the first point of data integration and helped guide the analysis later in the study.

**3.2.2 Phase two.** Phase two consisted of an initial set of interviews with preservice elementary school teachers in Ontario who agreed to be contacted for a follow up after the questionnaire. The interview was comprised of 10 questions (see Appendix A) and was conducted in person, or via a video chat program such as Skype, and recorded for transcription. Sixteen preservice teachers from four different universities in Ontario were interviewed. The preservice teachers were at various points of their Bachelor of Education program and therefore had different levels of classroom exposure through placement experiences. Prior to the interview, each interviewee was categorized based on their responses to the questionnaire. These categories were derived from their scores on the Revised Math Anxiety Rating Scale (measuring mathematics anxiety), the modified version of the Teaching Anxiety Scale (measuring mathematics teaching anxiety), and the modified version of the Teachers Sense of Efficacy Scale (measuring mathematics teacher efficacy) from the results of phase one. Each interviewee was coded as either high, moderate, or low for each of these three constructs. For example, an individual could be coded as having high mathematics anxiety, low mathematics teaching anxiety, and low mathematics teacher efficacy. The exact scoring process for each metric will be discussed in more detail in Chapter 4.

Of the sixteen preservice teachers interviewed, there was representation of at least two from each category of high, moderate, and low levels for each of the above constructs. This allowed for a robust analysis of the data and helped develop a portrait (Lawrence-Lightfoot & Hoffman Davis, 1997) of a preservice elementary school teacher with high, moderate, or low levels of a construct. Portraits were developed to give the reader another way to engage with the interpretation of the results. Portraiture is a qualitative research method where data gathered is used to develop a narrative that illustrates the lived experience. Portraiture allows for a narrative of the lived

experiences of the preservice elementary school teachers to be described. This narrative can help bridge the gap between the analysis of the data and the practical applications of the findings. For example, with the help of portraiture, a stereotypical mathematics anxious preservice teacher is now given a voice of their own and the reader is given another opportunity to experience what that is like and how these feelings could manifest. These portraits offer an approachable format for interpretation of the results and aid in the knowledge mobilization of the findings.

**3.2.3 Phase three.** Interviewees from phase two were contacted for an additional follow up interview after an initial analysis was performed on their interview data. The second set of interviews were done to allow me 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. Of the sixteen preservice teachers interviewed in phase two, six agreed to participate in a second interview and were interviewed again in this phase.

## 3.3 Ethical Considerations

Prior to data collection, clearance for this study was granted by the Education Research Ethics Board (EREB) and General Research Ethics Board (GREB) at Queen's University, TRAQ # 6025346 (Appendix B). Additionally, clearance for this study was granted by every additional university where preservice teachers were sampled from. Prior to being involved in any portion of the study, all participants were informed that their participation in the study was voluntary and they could withdraw from the study at any time without penalty. All information gathered from the interviews was sent back to the individual for confirmation that they and their ideas had been

portrayed accurately. After confirmation was acquired, all the information from the interview was de-identified using pseudonyms. Additionally, all information gathered from the questionnaire was also kept confidential using pseudonyms. All information gathered from this research was stored on a Queen's University OneDrive folder. This folder was held on encrypted servers which were password protected.

## 3.4 Participants

The participants of this study were preservice elementary school teachers enrolled in a teacher education program in Ontario, Canada. There are 12 universities in Ontario that provide teacher education programs. Of the 12 teacher education programs in Ontario, six universities agreed to be a part of the research (Brock University, Laurentian University, Nipissing University, Queen's University, Western University, and Windsor University). For the first phase, the online questionnaire was sent to each of the six teacher education programs that agreed to be a part of the research. This yielded 185 completed questionnaires for phase one, 16 participants for the interviews in the second phase, and 6 participants for the second round of interviews in the third phase.

## 3.5 Quantitative Data Collection Tools

The following section will give details of the instrumentation used in the questionnaire that was administered to the preservice teachers across Ontario. A description and rationale for using the Revised Mathematics Anxiety Scale, The Teaching Anxiety Scale, and the Teachers' Sense of Efficacy Scale is provided.

### 3.5.3 The Revised Mathematics Anxiety Rating Scale.

The Revised Mathematics Anxiety Rating Scale (RMARS) was developed by Alexander and Martray (1989) and was built as a modification to The Mathematics Anxiety Scale (MARS). The MARS was developed by

Richardson and Suinn (1972) and is a 98-item scale containing behavioural situations that could arouse feelings of mathematics anxiety. Data for the MARS were collected using a sample of 397 students in beginning education classes at the University of Missouri. The MARS was found to have strong reliability and validity and is one of the most used instruments for measuring mathematics anxiety. However, the RMARS was chosen over the MARS as the instrument to measure mathematics anxiety for two distinct reasons.

First, the underlying construct of the MARS is unidimensional (Richardson & Suinn, 1972; Suinn, Edie, Nicoletti & Spinelli, 1972), meaning it assumes that mathematics anxiety has no underlying constructs, however recent studies suggest there are multiple underlying constructs that contribute to mathematics anxiety (Wigfield & Meece, 1988; Ho et al., 2000; Harari, Vukovic & Bailey, 2013) such as test anxiety. The RMARS is a multidimensional instrument (Baloğlu & Zelhart, 2007) and measures mathematics anxiety using three subscales (Alexander, & Martray, 1989): mathematics test anxiety (student anxiety related to evaluative situations in mathematics), numerical task anxiety (student anxiety related to mathematics activities such as arithmetic), and mathematics course anxiety (student anxiety related to being in a mathematics classroom). These subscales are beneficial as they can help give a more detailed look at the individual being measured.

The second reason for the decision to use the RMARS instead of the MARS was length. With the questionnaire being comprised of three separate instruments the questionnaire runs the risk of being too long for participants to complete. To avoid a lengthy questionnaire that risks participant fatigue and losing the attention of the participants, the 25-item RMARS was chosen over the 98-item MARS.

The RMARS is a 25-item questionnaire comprised of the mathematics test anxiety subscale (15 items), numerical test anxiety subscale (five items), and the mathematical course anxiety subscale (five items). The items on the RMARS are on a 5-point scale with scores ranging from one (not at all) to five (very much). An individual can score as low as 25 and as high as 125 where a higher score corresponds to a higher level of overall mathematics anxiety (see Appendix C). The Cronbach alpha coefficient of the three subscales are .96, .84, and .86 respectively (Alexander & Martray, 1989) giving evidence of moderate-to-high reliability. Concurrent validity of the RMARS to the MARS was tested showing validity ($r = 0.93$, $p < 0.01$) between the two instruments.

For this study, one change was made to the original version of the RMARS. The question "Receiving your final grade in the mail" was changed to a more current "Receiving your final grade in an e-mail".

**3.5.4 The Teaching Anxiety Scale.** The Teaching Anxiety Scale (TCHAS) was developed by Parsons (1973) at Stanford University for use with preservice teachers. The TCHAS is comprised of self-report statements focused around two reactions to teaching: (a) emotional responses to a variety of different situations related to teaching and (b) attitudes toward teaching as a profession. This instrument was chosen because it was developed for preservice teachers specifically (as opposed to in-service teachers) and because the instrument is still commonly used to measure teaching anxiety (e.g., Cheung & Hui, 2011; Gorrow, Muller, & Schneider, 2005).

Minor alterations needed to be made to the TCHAS. Statements used in the scale were altered to reflect a mathematics classroom setting. 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". When the TCHAS was originally developed, two versions were produced: the TCHAS(1)-25 and TCHAS(2)-25. The decision to pick one version over the other was made based on trying to minimalize the alterations that needed to be done to the questions to fit this study. After reviewing the TCHAS(1)-25 and the TCHAS(2)-25 the statements used in the latter required the least amount of alteration to contextualize the statements in a mathematics classroom setting. Thus, the TCHAS(2)-25 was used for this study. For the ease of identification in this dissertation, the TCHAS(2)-25 will be referred to as the TCHAS for the remainder of the dissertation.

The TCHAS is comprised of 25 Likert scale items ranging from one (never) to five (always) (see Appendix C). Of the 25 questions in the survey, questions 2, 5, 8, 12, 13, 16, 17, 19, 20, 22, 24, and 25 are negatively worded and will be scored using reverse scoring. An individual's score can range from 25 to 125 after reverse coding the necessary items. A lower score on the TCHAS indicates a lower level of teaching anxiety while a higher score indicates a higher level of teaching anxiety.

**3.5.5 The Teachers' Sense of Efficacy Scale.** Tschannen-Moran and Woolfolk Hoy (2001) believed that the instrumentation most used to measure teacher efficacy at the time was inadequate. With eight graduate students in a seminar on self-efficacy in teaching and learning at the College of Education at the Ohio State University, Tschannen-Moran and Woolfolk Hoy developed the Teachers' Sense of Efficacy Scale (Tschannen-Moran & Woolfolk Hoy, 2001). The seminar group built the new instrument based on Bandura's (n.d.) unpublished scale of teacher self-efficacy. Three separate studies were subsequently carried out using the new instrument. These studies resulted in a 24-item form called the "long form," and a 12-item form

called the “short form.” For this study the short form of the TSES was used to minimize the total number of items on the questionnaire.

The short form TSES consists of 12 items on a 9-point Likert scale with one indicating “nothing”, five indicating “some degree”, and nine indicating “a great deal” (see Appendix C). An individual can score as low as 12 and as high as 108 with a lower score indicating a lower sense of teacher efficacy and a higher score indicating a higher sense of teacher efficacy. Using a factor analysis, Tschannen-Moran and Woolfolk Hoy (2001) found three underlying constructs: efficacy for instructional strategies (items 5, 9, 10, and 12), efficacy for classroom management (items 1, 6, 7, and 8), and efficacy for student engagement (items 2, 3, 4, and 11). The Cronbach alpha coefficient for these three subscales are .91, .90, and .87 respectively. Interestingly Tschannen-Moran and Woolfolk Hoy noted that “the factor structure for preservice teachers was less distinct, therefore it appeared that the best solution for preservice teachers was a single factor” (p. 800) and they suggested “for preservice teachers, the total score seems to be the most appropriate gauge of efficacy” (p. 801). The interpretation of teacher efficacy as a single factor was considered when analyzing the data given that the participants for this study were all preservice teachers.

### 3.6 Qualitative Data Collection Tools

An interview protocol containing 10 open-ended questions was developed and was structured to be approximately an hour in length. 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. 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 study.

The interview questions include the purpose and the construct(s) (mathematics anxiety, mathematics teaching anxiety, or mathematics teacher efficacy) that were intended to be discussed for each question underneath in italics (see Appendix A). Additionally, prompts for the interviewer are added for questions that have multiple constructs associated with them. If the response given by the interviewee discusses one or none of the constructs listed for that question, these prompts were used to generate discussion targeted toward each intended construct.

When developing the interview questions multiple studies centered around mathematics anxiety were used for reference. The 10-question interview protocol developed by Gresham (2007) stood as a foundation for the interview protocol used in this study. The protocol developed by Gresham was used in a study focused on preservice teachers' mathematics anxiety and was developed to compliment data collected from the MARS. Gresham developed the questions to gain a better understanding of preservice teachers' mathematics anxiety, mathematics self-efficacy, and mathematics teacher efficacy which is closely related to the research done in this study. Additionally, another study (Burleigh, 2017) used the interview protocol developed by Gresham and obtained relevant and accurate data pertaining to mathematics anxiety and mathematics teacher efficacy.

Seidman (2006) urges all researchers who use interviews to incorporate a pilot venture when designing an interview protocol. Before implementation of this interview protocol, one preservice teacher, one in-service teacher, one graduate student, and one academic researcher were interviewed to gain an understanding of length, appropriateness of questions, flow of

conversation, and recording and transcribing procedures. These pilot ventures were completed during phase one (Figure 1) while quantitative data was being collected.

### 3.7 Quantitative Data Analysis

Data collected from the online questionnaire was 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 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 interview participants into categories based on anxiety, teaching anxiety, and teacher efficacy (high, moderate, or low anxiety/teaching anxiety/teacher efficacy).

An individual can score as low as 25 and as high as 125 on the RMARS. The higher the score an individual receives, the higher their level of mathematics anxiety. For the purposes of this study, an individual was classified as being highly mathematics anxious with a score one standard deviation above the mean. Similarly, an individual was classified as having low mathematics anxiety with a score one standard deviation below the mean. It is important to note that using this method of classification means that individuals are classified in relation to other individuals in the study. This method of classification was chosen because preservice teachers are not an accurate representation of the general population. For example, in terms of education every participant has at least an undergraduate degree. The results gathered from the RMARS scores of preservice teachers in Ontario are expected to have a mean and standard deviation

different from that of the normal population. Classifying based on the scoring of the general population is not appropriate in this setting, instead preservice teachers were classified in relation to each other. Deciding on a specific score as a cut-off for high or low mathematics anxiety based on a provincial or nation-wide population sample seemed inappropriate. This classification method is described in greater detail in Chapter 4.

For the TCHAS, an individual can score as low as 25 and as high as 125. In keeping with the process used above for the RMARS, an individual was categorized as having high teaching anxiety if they scored higher than one standard deviation above the mean and individuals were categorized as having low teaching anxiety if they scored one standard deviation below the mean.

For the TSES an individual can score as low as 12 and as high as 108 with a higher score corresponding to a higher sense of mathematics teacher efficacy and a lower score corresponding to a lower sense of teacher efficacy. An individual was categorized as having low mathematics teacher efficacy and high mathematics teacher efficacy in the same manner as above for the RMARS and the TCHAS.

To verify that the TSES, RMARS, and TCHAS scales were performing as expected, a reliability check and factor confirmation was performed for each scale individually. For this, the Cronbach's $\alpha$ for each scale along with a confirmatory factor analysis and/or exploratory factor analysis using done using the data collected. Afterwards, with the individuals 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). The results discovered from this analysis helped answer the first sub-question of this research.

## 3.8 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 by the data which were then further compiled into themes.

For the coding procedure, thematic analysis following the steps outlined by Creswell (2007) (Figure 2) were used with minor adaptations to take advantage of current coding software. Additionally, given that the focus of this research is 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 another construct through the lens of the first. 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 perceives the other two constructs.

Triangulation, member checking, and inter-rater reliability were used to validate the findings of the qualitative analysis. Triangulation, in the context of validating qualitative data, is "the process of corroborating evidence from different individuals, types of data, or methods of

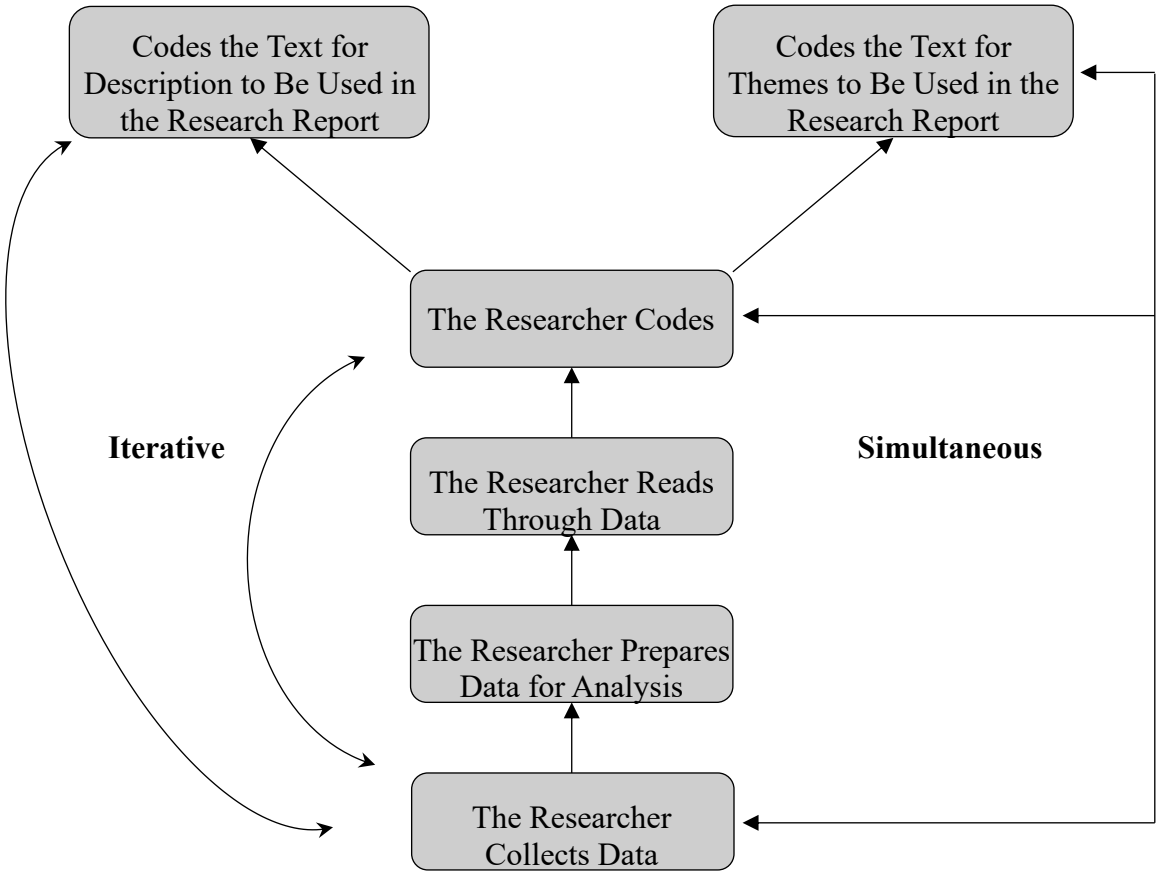


*Figure 2.* Steps for coding procedure as outlined by Creswell (2007).

data collection in descriptions and themes of qualitative research" (Creswell, 2012, p. 259). First, themes generated from the responses given by each individual participant were examined by looking for supporting evidence given by the other participants. During the coding procedure, if a theme was prominent with one preservice elementary school teacher from the interviews but was not experienced by any other preservice elementary school teacher the theme was not reported. This decision was made to allow for a focus on consistent themes across preservice elementary school teachers to be discussed as opposed to individual experiences. The consistent themes were then carried over to the questionnaire. Supporting evidence for these themes were then pulled in from the short answer responses. Finally, these themes were then referenced with

what is known in the literature. Drawing on multiple sources of information allowed for a more credible and accurate conclusion to be drawn from the data.

Member checking is the process where the researcher solicits the participants' views of the credibility of findings and interpretations. For this study, transcriptions were made shortly after each interview was completed. A transcript was then emailed to each interviewee who were then asked to read through the text to verify the interpretations were fair, accurate, and representative of what the interviewee was trying to convey. The interviewees were made aware that they could remove any or all parts of their interview and make any changes they felt necessary. After all participants had a chance to make changes, nothing was removed or changed from the interviews. The member checking process was completed prior to analysis and helped maintain a strong sense of credibility and trustworthiness throughout.

For the coding procedure, two external reviewers were used for inter-rater reliability. A current PhD student in the field of education research as well as a professor at a Faculty of Education who is experienced in coding and analyzing qualitative data were asked to help. The two external reviewers and the researcher met to ensure the purpose of the research, coding procedure being used, and a fundamental understanding of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy was understood. A modified process of inter-rater reliability, as described by Creswell (2007), was used. The researcher and two external reviewers analyzed and coded one interview transcription together and develop a codebook (Appendix D). This codebook contained a definition of each code used and a text segment to accompany it. All three individuals then independently coded a second transcript using the codebook, adding any additional codes as necessary. The researcher and reviewers met and compared their results until 100% agreement was made for each piece until moving on.

The short answer responses from the questionnaire served as a second source of qualitative data. The short answer responses were categorized as being high, medium, or low for all three constructs, then the responses were separated based on their category. Next, the short answer responses from each individual category were coded using the corresponding themes found in the interview data. For example, the category high mathematics teaching anxiety had two themes: *good student, poor student experience* and *reliance on resources*. The short answer responses in the high mathematics teaching anxiety category were reread and coded *a priori* once for any examples of the first theme *good student, poor student experience* and then again for the second theme *reliance on resources*. This process was repeated for all the categories until all short answer responses from the questionnaire had been coded.

### 3.9 Mixing and Integrating the Data

The integration of this mixed methods study happened at two distinct instances (Figure 1). The first point of integration was the use of the quantitative data to categorize the participants into high/moderate/low mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy. This quantitative data was gathered from the responses to the RMARS, TCHAS, and TSES section of the questionnaire.

The second point of integration occurred when combining the quantitative and qualitative analysis results in the interpretation and discussion portion of the research. The quantitative analyses provided information regarding the correlations of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy. These correlations provided a foundation of understanding about the interactions of the constructs which in turn provided a framework for the qualitative analysis to build upon. For example, the quantitative analysis showed a correlation between mathematics anxiety and mathematics teaching anxiety and so the qualitative data was

interpreted with this mind. Additionally, there was no correlation between mathematics anxiety and mathematics teacher efficacy in the quantitative analysis. The need to understand this lack of correlation guided the qualitative data analyses. Furthermore, the results from the quantitative analyses and the qualitative analyses provide a breadth and depth to the results that contributed to the development of the portraits.

### 3.10 Portraiture

Portraiture (Lawrence-Lightfoot & Davis, 1997) is the process where the researcher uses forms of inquiry to describe a phenomenon while allowing for the esthetic properties of the data to be seen. Portraiture is valuable in educational research because it helps bridge narrative inquiry with the empirical understanding of the context (Lawrence-Lightfoot & Davis, 1997) and has been used frequently in educational research (Hackmann, 2010; Harding, 2005; Lynn, 2006; Larkin, Seyforth, & Lasky, 2009; Mulholland & Wallace, 2005). Portraiture is framed around the combination of rigorous description, interpretation, analysis, and synthesis with an aesthetic packaging of narrative development (Lawrence-Lightfoot & Hoffman Davis, 1997). Hampsten (2015) explained that portraiture offers an opportunity to capture the paradoxes and individual complexities of lived experiences. Lawrence-Lightfoot and Davis (1997) describe the five components of portraiture: context, voice, relationship, emergent themes, and the aesthetic whole which are used to create an authentic interpretation of the setting and participants. They describe the fifth component, nothing that:

> In constructing the aesthetic whole, the portraitist seeks a portrayal that is believable, that makes sense, that causes that "click of recognition." We refer to this "yes of course" experience as a resonance, and we see the standard as one of authenticity. (p. 247)

Expressing the analysis of the data using portraiture, the "click of recognition" is used to help with the understanding and recognition of the experiences of preservice teachers in Ontario. Using current literature along with qualitative and quantitative data gathered from this study, portraiture is used to give a narrative of the common experiences of preservice elementary school teachers in Ontario with high/low mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy.

Portraiture also serves as a valuable tool for future knowledge mobilization of the results. Quigley, Trauth-Nare and Beeman-Cadwallader (2015) discuss this in their paper on the viability of portraiture for science education research:

> Conducting portraiture research provides a conduit through which researchers can frame and interpret stories that move the conversation from the realm of theory (i.e., academy) back to policy (i.e., teacher education) and practice (i.e., classrooms and the communities in which they are located). (pp. 40–41)

Using portraiture is not the only method of communicating the results of this study but for some readers it may be the most impactful. While this research is presented with an academic audience in mind, the use of portraiture can help expand the impact of the results to other key stakeholders in terms of mathematics education—namely administration, preservice teachers, and in-service teachers. It is important to reach these audiences as well because they hold as much power to impact preservice elementary school teachers if not more than educational researchers. The portraits work to provide that "click of recognition" for administration, preservice and in-service teachers so that they can recognize when a colleague is struggling.

In this study, seven portraits were created. Six of the seven portraits portray preservice teachers with one of either high or low mathematics anxiety, mathematics teaching anxiety, or

mathematics teacher efficacy (high mathematics anxiety, low mathematics anxiety, high mathematics teaching anxiety, low mathematics teaching anxiety, high mathematics teacher efficacy, and low mathematics teacher efficacy) with the seventh portrait depicting an individual who represents the *typical* preservice teacher. The portrait of the *typical* preservice teacher depicts a preservice teacher who scored average on all three measures for mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy.

To create these portraits the interviewees and their coded interviews were separated into categories of high, medium, or low mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy based on questionnaire results. Additionally, the responses given to the short answer question from the questionnaire were separated into these categories based on the results from the questionnaire (Table 1). This enabled the researcher to separate the qualitative data into "bins" based on the levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy. This categorization allowed for individuals to be represented in multiple bins. For example, the coded interview data from and individual with high mathematics teacher efficacy, low mathematics anxiety, and average mathematics teaching anxiety would be put into two bins (high mathematics teacher efficacy bin and low mathematics anxiety bin). There was no "average bin" for each individual construct, instead there was one "large bin" created to hold the data from preservice teachers who scored average on all three constructs. Using the data in these bins, the seven portraits were created.

### 3.11 Inferencing and Concluding

With the qualitative and quantitative analyses completed the research question and sub-questions were re-examined. The first sub-question, "what is the relationship between

Table 1

*Categorization of Interviewees and Short Answer Responses*

| | Mathematics Anxiety | Mathematics Teaching Anxiety | Mathematics Teacher Efficacy |
|---|---|---|---|
| **High Bin** | 2 Interviews<br>23 Short Answer Responses | 2 Interviews<br>25 Short Answer Responses | 2 Interviews<br>21 Short Answer Responses |
| **Average Bin** | | 7 Interviews<br>42 Short Answer Responses | |
| **Low Bin** | 2 Interviews<br>28 Short Answer Responses | 4 Interviews<br>26 Short Answer Responses | 4 Interviews<br>23 Short Answer Responses |

mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy", can primarily be answered through the quantitative results. The correlational analyses amongst the RMARS, TCHAS, and TSES provides valuable insight into the relationship between these three constructs. These results, along with multiples analysis of variances (ANOVAs), allowed for a discussion to be had about the first sub question later in this dissertation.

For the second sub-question, "how are varying levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy experienced in elementary

school preservice teacher in Ontario?", the qualitative results serve as the primary data source. The themes generated from the interviews and short answer responses allow for a deeper look into the experiences these preservice teachers have had. The data collected through the interviews and short answer responses help give shape to how the varying levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy impact a preservice teacher during their teacher education program, both in their mathematics methods course as well as their placement experiences in elementary classrooms.

Together these sub-questions help answer the overarching research question: "what role does mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy have on preservice elementary school teachers in Ontario?" Here is where the major benefit of a mixed methods research design comes into play. The quantitative results were used to give an overarching picture of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy in preservice elementary school teachers in Ontario, including the levels these constructs have in preservice elementary school teachers in Ontario and to what extent these relationships relate to one another. Then, with a general view of these constructs, the qualitative results were leveraged to give depth to the results. These two data sources in tandem with current literature surrounding mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy, allow for concluding remarks and inferences to be made about the overarching research question.

In the following chapter, the results from the quantitative and qualitative research will be presented. These results include the demographic information, reliability, and validity calculations for all the measures, and the results from the qualitative analyses of the interviews.

# Chapter Four – Results

This chapter will outline the quantitative results from the online survey that was distributed to preservice teachers across Ontario and the qualitative results from the analysis of the interviews conducted with the 16 preservice teachers. Demographic information of the questionnaire participants will be provided followed by the results of validity and reliability analyses done on the Revised Mathematics Anxiety Rating Scale (RMARS), Teaching Anxiety Scale (TCHAS), and Teachers' Sense of Efficacy Scale (TSES). Finally, results from the qualitative analysis of the interviews will be discussed.

## 4.1 Results from Quantitative Analyses

Quantitative analyses were conducted on the data collected from the questionnaire administered to preservice teachers across Ontario. These analyses include demographic analyses, analyses done on the three instruments to ensure their reliability and validity, as well as a correlational analysis between the three constructs and multiple analysis of variances (ANOVAs) to investigate the interaction of mathematics anxiety, mathematics teaching anxiety and mathematics teacher efficacy. The results are given below.

**4.1.1 Demographics.** The online survey was completed by 185 elementary school preservice teachers from 6 different universities across Ontario (Table 2) with the majority of the participants identifying as female (87%). This gender difference is typical of preservice elementary school teachers. Because of this predominantly female representation, gender is not explored in this research as the underrepresentation of the male experience does not allow for a sound comparison. In Ontario, elementary education refers to teachers who teach kindergarten to grade six. This includes students from the ages of 4 to 11. The participants varied in the number of instructional hours spent in a mathematics curriculum course (Table 3) and 60% had

completed no more than one mathematics course in their undergraduate degree. Additionally, only 10% had an undergraduate major in a traditional STEM field.

Table 2

*Respondents by University*

| University | n | % |
|---|---|---|
| Brock University | 53 | 29 |
| Laurentian University | 11 | 6 |
| Nipissing University | 31 | 17 |
| Queen's University | 27 | 14 |
| Western University | 52 | 28 |
| Windsor University | 11 | 6 |

Table 3

*Respondents by Hours Spent in Mathematics Curriculum Course*

| Hours | n | % |
|---|---|---|
| 0 | 18 | 10 |
| 1-10 | 3 | 2 |
| 11-20 | 17 | 9 |
| 21-30 | 76 | 41 |
| 31-40 | 29 | 16 |
| 41-50 | 7 | 4 |
| 51-60 | 15 | 8 |
| 61+ | 20 | 10 |

Mathematics curriculum courses in Ontario can vary in content and instructional approach, but typically they include instruction regarding mathematical content, use of mathematical manipulatives, instruction in best teaching practices in mathematics (number talks, differentiated mathematical instruction, etc.) as well as strategies for assessment in mathematics, with a focus on the Ontario mathematics curricula.

**4.1.2 The Revised Mathematics Anxiety Rating Scale (RMARS) analyses.** The following section describes the results of the analyses conducted on the RMARS portion of the survey. Specifically, a confirmatory factor analysis, exploratory factor analysis, and a reliability check was computed. The results are shown below.

***Confirmatory factor analysis of the RMARS.*** The RMARS is a multidimensional instrument (Baloğlu & Zelhart, 2007). The RMARS is comprised of mathematical test anxiety, numerical task anxiety, and mathematical course anxiety. To check for validity of this instrument a confirmatory factor analysis (CFA) was carried out using SPSS Version 25 and AMOS. Figure 3 shows the results of this analysis.

A popular measure of fit for a CFA is the Root Mean Square Error of Approximation (RMSEA). MacCallum, Browne, and Sugawara (1996) have used a RMSEA of 0.01, 0.05, and 0.08 to indicate excellent, good, and mediocre fit, respectively. However, others have suggested that 0.1 should be the cut-off for poor fitting models. The CFA on the results of the RMARS from this sturdy yielded a RMSEA of 0.101 which is extremely close to the cut-off point, but ultimately still above the cut-off point. To take a closer look into this, an exploratory factor analysis was done to see if there was a better loading of factors.

***Exploratory factor analysis of RMARS.*** A principal factor analysis was conducted on 25 items with oblique rotation. An oblique rotation was chosen over an orthogonal rotation because

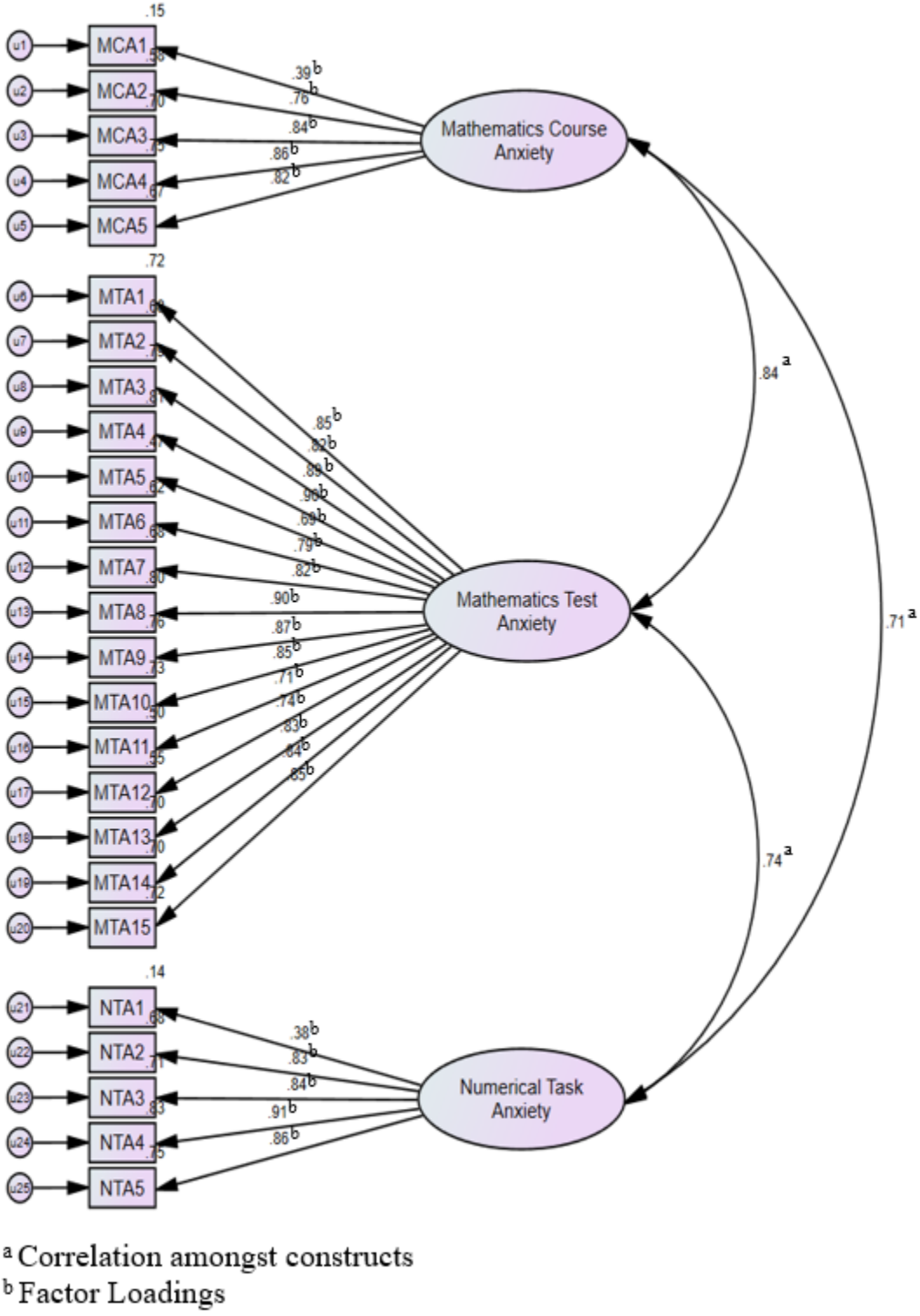


*Figure 3*. Results from confirmatory factor analysis on RMARS.

prior analysis showed correlation between the factors. The Kaiser-Meyer-Olkin (KMO) measure verified sampling adequacy for analysis with KMO=0.96 which is “marvelous” according to Kaiser and Rice (1974). Additionally, all KMO values for individual items were greater than 0.837 which is well above the acceptable minimum of 0.5 (Kaiser and Rice, 1974).

In the analysis three factors had eigenvalues over Kaiser’s criterion of 1 and in combination explained over 71.46% of the variance. The Scree Plot below (Figure 4) shows an inflection point at four which justifies keeping three factors. Table 4 shows the factor loadings after the oblique rotation. Looking at the clustering of items and their factor loadings it looks like the three factors of mathematics test anxiety, numerical task anxiety, and mathematics course anxiety are valid factors.

Interestingly, it looks like the item “Reading a cash register receipt after your purchase” is the only item that does not properly load. This item is supposed to load onto the numerical task anxiety factor, but it loads weakly onto the mathematics course anxiety. A closer examination of

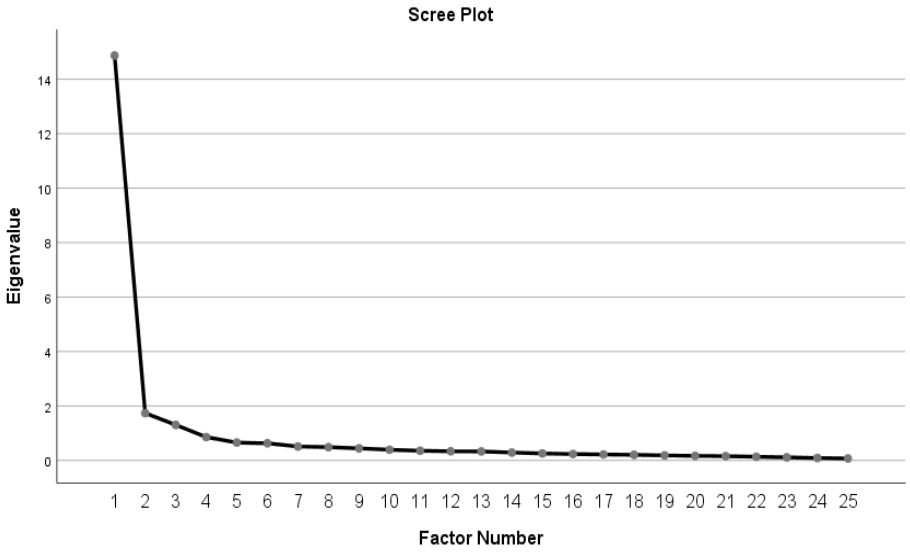


*Figure 4.* Scree Plot for RMARS.

the analysis indicates that this item does not load onto either factor nicely so it might be an item that should be omitted completely from the questionnaire in future use.

Table 4

*Factor Loadings for RMARS after oblique rotation*

| | **Factor Loadings** | | |
|---|---|---|---|
| | *Mathematics Test Anxiety* | *Numerical Task Anxiety* | *Mathematics Course Anxiety* |
| Taking an exam (final) in a math course | **1.003** | | |
| Thinking about an upcoming math test 1 day before | **0.984** | | |
| Thinking about an upcoming math test 1 hour before | **0.934** | | |
| Taking an exam (quiz) in a math course | **0.906** | | |
| Being given a "pop" quiz in a math class | **0.884** | | |
| Taking the math section of a college entrance exam | **0.8** | | |
| Getting ready to study for a math test | **0.766** | | |
| Realizing you have to take a certain number of math classes to fulfill requirements | **0.761** | | |
| Thinking about an upcoming math test 1 week before | **0.761** | | |
| Studying for a math test | **0.751** | | |
| Receiving your final math grade in an email | **0.729** | | |

| | | | |
|---|---|---|---|
| Opening a math or statistics book and seeing a page full or problems | **0.660** | | |
| Being given homework assignments of many difficult problems that are due the next class meeting | **0.637** | | |
| Signing up for a math course | 0.613 | | **0.365** |
| Walking into a math class | 0.448 | | **0.334** |
| Picking up a math textbook to begin a difficult reading assignment. | **0.442** | | 0.344 |
| Being given a set of multiplication problems to solve | | **1.021** | |
| Being given a set of subtraction problems to solve | | **0.856** | |
| Being given a set of division problems to solve | | **0.714** | |
| Being given a set of numerical problems | | **0.577** | |
| Buying a mathematics textbook | | | **0.665** |
| Listening to another student (or teacher) explain a math formula | 0.441 | | **0.584** |
| Watching a teacher (or student) work on an algebraic equation on the blackboard | | | **0.459** |
| Picking up a math textbook to begin working on a homework assignment | **0.320** | | 0.362 |
| Reading a cash register receipt after your purchase | | | **0.313** |

Note: Factor loadings below 0.3 are omitted.
Bolded numbers indicate selected factor

***Reliability of RMARS.*** Cronbach (1951) suggested that if an instrument has several factors then the formula for reliability should be applied separately to the items that relate to different factors. The RMARS has three factors: mathematics test anxiety, numerical task anxiety, and mathematics course anxiety. An analysis of the reliability of these three factors yielded α=.969, α=.878, and α=.858 for these factors, respectively. A more detailed analysis is given below.

*Mathematics test anxiety.* The Cronbach's alpha for this factor was calculated to be α= .969 which according to Kline (2000) indicates "excellent" internal consistency. All corrected item-total correlations were above 0.3 with the lowest being 0.704. This indicates that all the questions in this factor fit the scale well. Finally, no items indicated an increase in α if deleted.

*Numerical task anxiety.* The Cronbach's alpha for this factor was calculated to be α= .878 which according to Kline (2000) indicates "good" internal consistency. All corrected item-total correlations were above 0.3 with the lowest being 0.367. This indicates that all the questions in this factor fit the scale well. Finally, the item "reading a cash register receipt after your purchase" indicated an increase in α from α= .878 to α= .916 if removed from the instrument. This is anticipated considering the factor loading for this item which was discussed above. The decision to keep this question included in the analysis was made because the increase in α was minimal when this item was removed and this research will be comparing results with other papers that used the RMARS as an instrument to measure mathematics anxiety, so maintaining this item will allow for comparison with other research.

*Mathematics course anxiety.* The Cronbach's alpha for this factor was calculated to be α= .858 which according to Kline (2000) indicates "good" internal consistency. All corrected item-total correlations were above 0.3 with the lowest being 0.41. This indicates that all the questions

in this factor fit the scale well. Finally, the item “Buying a mathematics textbook” indicated an increase in α from α= .858 to α= .888 if removed from the instrument. The decision to keep this question included in the analysis was made because the increase in α when this item was removed was minimal and this research will be comparing results with other papers that used the RMARS, so maintaining this item will allow for comparison with other research.

In conclusion all three factors have good levels of Cronbach’s alpha which indicate a good reliability of the instrument.

**4.1.3 The Teaching Anxiety Scale (TCHAS) analysis.** The following section describes the results of the analyses done on results from the TCHAS. Specifically, an exploratory factor analysis and a reliability check was computed. The results are shown below.

***Exploratory factor analysis of TCHAS.*** Current literature on the TCHAS suggests that this instrument is univariable (Parsons, 1973). To confirm validity of this instrument, an exploratory factor analysis was done on the results of the TCHAS from this questionnaire. The questionnaire used in this study was a modified version of the original TCHAS. This modification was done to place the teaching scenarios of the items in the instrument in a mathematics classroom setting. Because of this modification an exploratory factor analysis is needed. The following are the details and results from this analysis.

A principal axis factor analysis was conducted on the 25 items of the TCHAS using an orthogonal rotation. The Kaiser-Meyer-Olkin (KMO) measure verified the sampling adequacy for the analysis with KMO= .91. This is deemed “marvelous” according to Kaiser and Rice (1974). All KMO values for individual items were above the minimum 0.5 except for the question “I feel certain I really want to be a teacher” with KMO= .484. This would suggest considering removal of the question from the instrument, but in order to keep the instrument

complete for a more accurate comparison to other literature using this instrument it will be kept as the KMO value is still considerably close to the recommended 0.5.

An initial analysis was run to obtain eigenvalues for each factor of the data. Five factors had an eigenvalue over Kaiser's criterion of 1, but it is important to bring to the attention that factors 6, 7, and 8 were very close with eigenvalues 0.927, 0.832, and 0.789, respectively. The combination of five eigenvalues over 1 accounted for a total of 61% of the variance. The Scree Plot (Figure 5) was ambiguous about the inflection point at the level of 3, 4, and 5. Table 5 shows the factor loadings for the TCHAS.

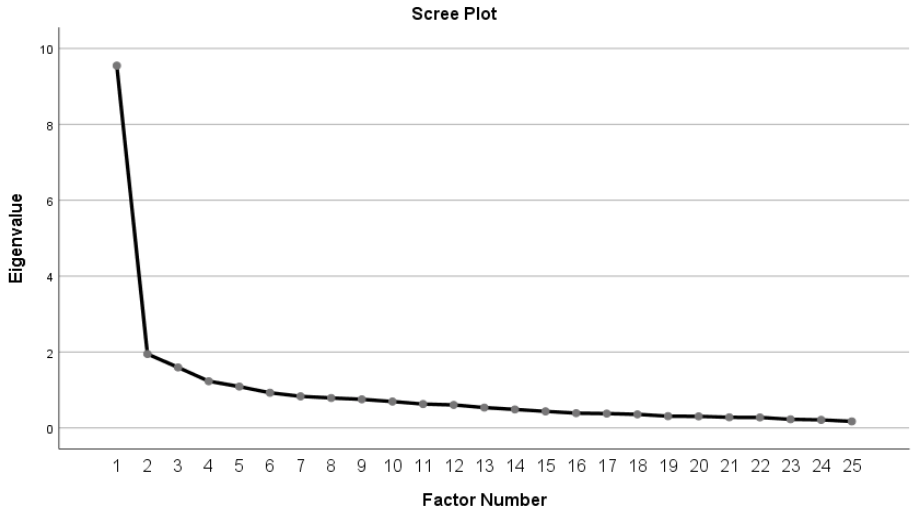


*Figure 5.* Scree Plot for TCHAS.

As can be seen in Table 5, 17 of the questions load onto a single factor with the other factors only containing two questions each. After examining the questions in these groupings no themes emerge from these factors except for factor 3 which contains the two questions "I feel certain I really want to be a teacher" and "I'm worried whether I will find teaching a satisfying position". These two questions seem to share a distinct feature about being confident in their decision to be in the teaching profession.

After noticing this factor loading, a principal factor analysis was rerun with parameters set to force the analysis to output only two factors. This procedure, unfortunately, yielded results that did not fit any discernable pattern either. This result does not support having the TCHAS with two factors—one large factor and one smaller factor of being confident in the teaching profession.

Table 5

*Multiple Factor Loadings for TCHAS*

| | **Factor Loadings** | | | | |
|---|---|---|---|---|---|
| | *Factor 1* | *Factor 2* | *Factor 3* | *Factor 4* | *Factor 5* |
| I'm afraid other teachers will think I'm incompetent at teaching my students math. | **0.826** | | | | |
| I would feel anxious when preparing math lessons. | **0.796** | | | | |
| I feel uncertain about my ability to improvise in the math classroom. | **0.753** | | | | |
| I feel less well prepared for teaching math than other preservice teachers in my program. | **0.701** | | | | |
| I feel I will be less competent in the math classroom than other preservice teachers in my teacher preparation. | **0.687** | | | | |
| I feel anxious about my ability to keep a math class under control. | **0.686** | | | | |

| | | | | |
|---|---|---|---|---|
| I feel that I am as good at teaching math as the other preservice teachers in my program. | **0.667** | | | 0.431 |
| I'm afraid students won't follow my math instructions. | **0.643** | | | |
| I feel sure I can be a good math teacher | **0.632** | 0.360 | | 0.395 |
| I'm afraid I will forget everything I know when I get in front of a class to teach a math lesson. | **0.61** | | | |
| I would feel edgy and nervous if a student's parent observed a math lesson in my classroom. | **0.580** | | 0.407 | |
| I feel comfortable speaking about math in front of a group. | **0.557** | 0.328 | | |
| I would feel calm and collected even when a student asks me a math question I couldn't answer. | **0.536** | 0.392 | | |
| I feel at ease when I am being observed by my university supervisor while teaching a math lesson. | **0.523** | 0.402 | | |
| I feel certain about my ability to keep the class interested during a math lesson. | **0.501** | 0.417 | | |
| I'll be happier teaching a math class than I originally thought I would be. | **0.414** | 0.337 | | |

| | | | | | |
|---|---|---|---|---|---|
| I would find it difficult to admit that I don't know the answer to a math question that a student asked. | **0.413** | | | | |
| I would feel calm if the principal informed me they were coming to my math class to observe. | | **0.580** | | | |
| Even if I had trouble answering a student's math question, I would find it easy to concentrate on questions that follow. | | **0.458** | | | |
| The thought of holding parent-teacher conferences makes me feel panicky. | | | **0.666** | | |
| I would be afraid to speak up in the staff room. | | | **0.630** | | |
| I feel certain I really want to be a teacher. | | | | **0.924** | |
| I'm worried whether I will find teaching a satisfying profession. | | | | **0.634** | |
| I would be able to decide how to present math information in the classroom with a feeling of uncertainty. | | | | | |
| Good rapport with my students will be one of my strong points. | | | | | **0.534** |

Note: Factor loadings below 0.3 are omitted, bolded numbers are selected factor

The initial exploratory factor analysis showed 17 of the 25 questions loaded onto a single factor with the remaining four factors only having two items each and each factor had no discernable theme except for factor 3. Based on this initial exploratory factor analysis and with the prior research behind the TCHAS supporting this, I would agree that the TCHAS is a unidimensional instrument. To verify this, another principal axis factor analysis was conducted on the 25 items of the TCHAS except this time the analysis was forced to produce only one factor.

As we are forcing one factor the rotation for this analysis is irrelevant. The Kaiser-Meyer-Olkin (KMO) measure verified the sampling adequacy for the analysis with KMO= .91. This is deemed "marvelous" according to Kaiser and Rice (1974). All KMO values for individual items were above the minimum 0.5 except for the question "I feel certain I really want to be a teacher" with KMO= .484, as was seen above. Again, this would suggest considering removal of the question form the instrument, but in order to keep the instrument complete for a more accurate comparison to other literature using this instrument it will be kept as the KMO value is still considerably close to the recommended 0.5. The factor loadings for the analysis can be seen in Table 6. All questions load onto a single factor although the last three questions load weakly. For comparison with other research that use this instrument all 25 questions will remain through the analysis.

***Reliability of TCHAS.*** As discussed earlier, the TCHAS is considered a univariate instrument, but previous analysis suggested the removal of three questions. An overall Cronbach alpha for the TCHAS without any questions removed was $\alpha = .916$ which is strong. Three

Table 6

*Single Factor Loadings for TCHAS*

| | **Factor Loadings** |
|---|---|
| | *Factor 1* |
| I'm afraid other teachers will think I'm incompetent at teaching my students math. | .832 |
| I would feel anxious when preparing math lessons. | .780 |
| I feel sure I can be a good math teacher. | .749 |
| I feel uncertain about my ability to improvise in the math classroom. | .743 |
| I feel at ease when I am being observed by my university supervisor while teaching a math lesson. | .728 |
| I feel I will be less competent in the math classroom than other preservice teachers in my teacher preparation. | .717 |
| I'm afraid I will forget everything I know when I get in front of a class to teach a math lesson. | .714 |
| I feel that I am as good at teaching math as the other preservice teachers in my program. | .712 |
| I would feel calm and collected even when a student asks me a math question I couldn't answer. | .710 |
| I feel anxious about my ability to keep a math class under control. | .708 |
| I feel less well prepared for teaching math than other preservice teachers in my program. | .701 |
| I would feel edgy and nervous if a student's parent observed a math lesson in my classroom. | .699 |
| I'm afraid students won't follow my math instructions. | .692 |
| I feel certain about my ability to keep the class interested during a math lesson. | .649 |

| | |
|---|---|
| I feel comfortable speaking about math in front of a group. | .609 |
| I would be afraid to speak up in the staff room. | .488 |
| I would feel calm if the principal informed me they were coming to my math class to observe. | .466 |
| I would find it difficult to admit that I don't know the answer to a math question that a student asked. | .459 |
| I'll be happier teaching a math class than I originally thought I would be. | .448 |
| Even if I had trouble answering a student's math question, I would find it easy to concentrate on questions that follow. | .325 |
| I would be able to decide how to present math information in the classroom with a feeling of uncertainty. | -.313 |
| The thought of holding parent-teacher conferences makes me feel panicky. | .306 |
| Good rapport with my students will be one of my strong points. | .239 |
| I'm worried whether I will find teaching a satisfying profession. | .228 |
| I feel certain I really want to be a teacher. | .126 |

questions indicated an increase to α if removed, but this increase was relatively minimal. The analysis was rerun with the removal of the three questions that the exploratory factor analysis suggested to be removed. One overall Cronbach's alpha was computed for the remaining 22 items. The modified TCHAS instrument has a Cronbach's alpha of α= .923 which is also high. No questions indicated an increase to α if removed. With the reliability still being high if all questions remain in the TCHAS, the decision was made to not modify the TCHAS so comparisons can be made with other research that use this instrument.

**4.1.4 The Teacher's Sense of Efficacy Scale (TSES) analysis.** The following section describes the results of the analyses from the TSES portion of the survey. Specifically, a confirmatory factor analysis and a reliability check was computed. The results are shown below.

***Confirmatory factor analysis for TSES.*** The TSES is a multidimensional instrument comprised of the three factors e*fficacy for instructional strategies, efficacy for classroom management,* and *efficacy for student engagement* (Tschannen-Moran & Hoy, 2001). In order to check for validity of this instrument a CFA was done using SPSS Version 25 and AMOS—Figure 6 shows the results. The CFA on the results of the TSES from this study yielded a RMSEA of 0.068 which is between a good and mediocre fit to the anticipated loadings.

***Reliability of TSES.*** The Cronbach's alpha for the three subscales of the TSES were calculated to be α= .871, α= .863, and α= .855 for *efficacy for instructional strategies, efficacy for classroom management,* and *efficacy for student engagement* which are all high. A more detailed description of the analyses is given below.

*Efficacy for instructional strategies.* The Cronbach's alpha for this factor was calculated to be α= .871 which according to Kline (2000) indicates "good" internal consistency. All corrected item-total correlations were above 0.3 with the lowest being 0.655. This indicates that all the questions in this factor fit the scale well. Finally, no items indicated an increase in α if deleted.

*Efficacy for classroom management.* The Cronbach's alpha for this factor was calculated to be α= .863 which according to Kline (2000) indicates "good" internal consistency. All corrected item-total correlations were above 0.3 with the lowest being 0.629. This indicates that all the questions in this factor fit the scale well. Finally, no items indicated an increase in α if deleted.

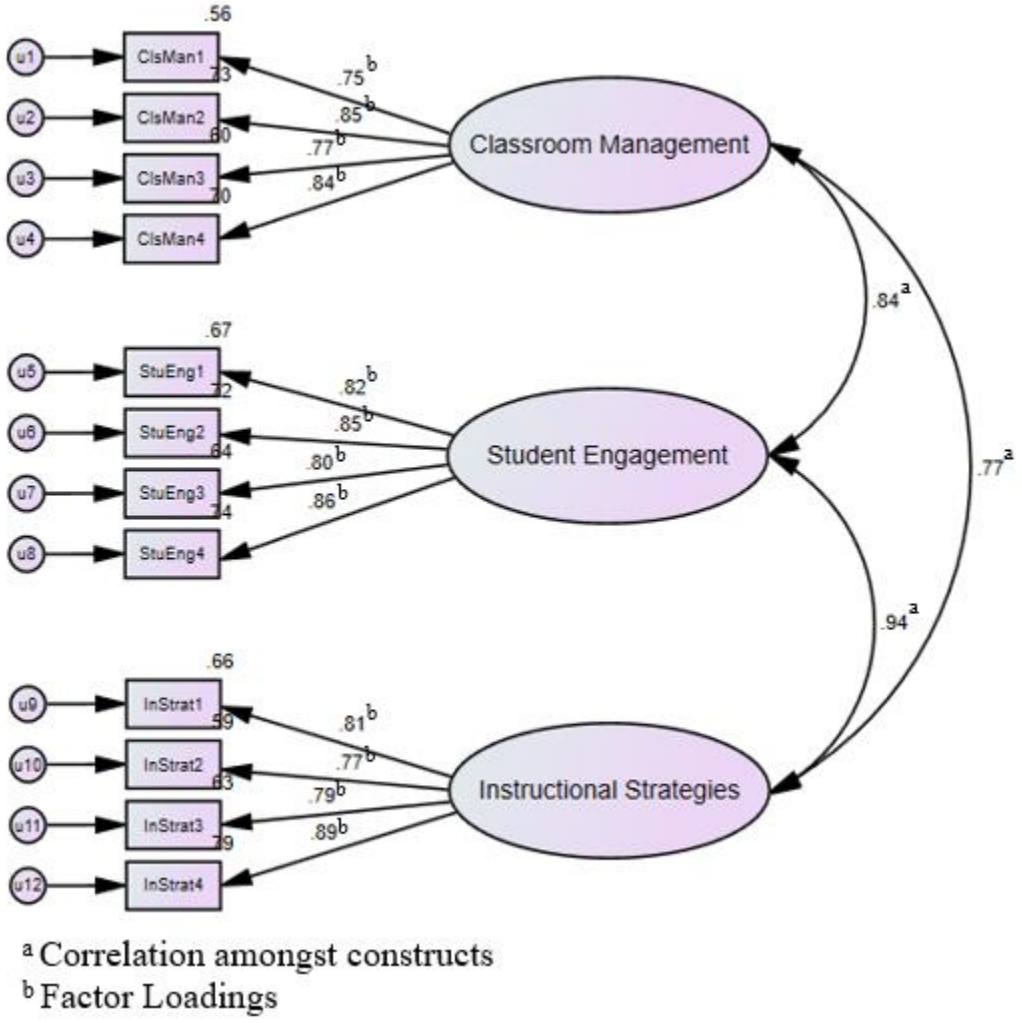


*Figure 6*. Confirmatory factor analysis for TSES.

*Efficacy for student engagement.* The Cronbach's alpha for this factor was calculated to be α= .855 which according to Kline (2000) indicates "good" internal consistency. All corrected item-total correlations were above 0.3 with the lowest being 0.595. This indicates that all the questions in this factor fit the scale well. Finally, the question "how much can you assist families in helping their children do well in math?" indicated an increase in α from α= .855 to α= .867 if removed from the instrument. The decision to keep this question included in the analysis was

made because the increase in α was minimal and this research will be comparing results with other papers that used the TSES.

In conclusion, all three factors have good levels of Cronbach's alpha which indicate a good reliability of the instrument.

**4.1.5 Correlations between RMARS, TCHAS, and TSES.** To examine the relationship between mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy a two-tailed bivariate correlation analysis was done with the RMARS, TSES, TCHAS, and their respective subfactors using a Pearson correlation coefficient Table 7 shows the results for each instrument and its subfactors.

Many of the correlations that were calculated as a result of the correlational analysis are in alignment with the literature. Specifically, it was discussed in previous chapters that mathematics anxiety and mathematics teaching anxiety have been found to be positively correlated (Adeyemi, 2015; Haciomeroglu, 2014), mathematics anxiety and mathematics teacher efficacy negatively correlated (Gresham, 2008; Unlu, Ertekin, & Dimac, 2017) , and mathematics teaching anxiety and mathematics teacher efficacy also negatively correlated (Peker, 2016). Table 7 shows the same results as Table 8 except the expected results have been removed for easier interpretation by the reader. Although many of the expected correlations emerged, there are still notable correlations or lack of correlations that emerged from the correlational analysis. Specifically, it is interesting to note that the TCHAS (which measured mathematics teaching anxiety) had a significant positive correlation with the RMARS (which measured mathematics anxiety) and a significant negative correlation with the TSES (which measured mathematics teacher efficacy).

Table 7

*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*** | 1 | **.734**** | **.768**** | **.979**** | **.690**** | **-.271**** | -.001 | -.136 | **-.159*** |
| **RMARS** ***Numerical Task Anxiety*** | | 1 | **.661**** | **.829**** | **.508**** | -.026 | .055 | .046 | .025 |
| **RMARS** ***Math Course Anxiety*** | | | 1 | **.853**** | **.565**** | **-.251**** | -.069 | **-.172*** | **-.187*** |
| **RMARS** ***Total*** | | | | 1 | **.682**** | **-.240**** | -.003 | -.118 | -.141 |
| **TCHAS** ***Total*** | | | | | 1 | **-.457**** | **-.285**** | **-.373**** | **-.417**** |

| | | | | |
|---|---|---|---|---|
| **TSES *Efficacy for Instructional Strategies*** | 1 | **.663**** | **.791**** | **.916**** |
| **TSES *Efficacy for Classroom Management*** | | 1 | **.716**** | **.869**** |
| **TSES *Efficacy for Student Engagement*** | | | 1 | **.924**** |
| **TSES *Total*** | | | | 1 |

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

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

Note: Significant correlations are shown in bold.

Note: Redundant information below the diagonal has been removed.

Table 8

*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**** |

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

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

This is hypothesized to be true but is notable as there is a lack of other research focused on mathematics *teaching* anxiety and its interactions with mathematics anxiety and mathematics teacher efficacy.

Additionally, it is interesting to note that there is a lack of correlation between the RMARS (mathematics anxiety) and the TSES (mathematics teacher efficacy). This is notable as it does not follow current literature which shows a negative correlation between mathematics anxiety and mathematics teacher efficacy. This is only noted here but will be discussed further in subsequent chapters.

**4.1.6 Analysis of Variance (ANOVA).** To determine if any group differences existed, ANOVAs were computed. This form of analysis helps provide insight into the interactions amongst the three constructs: mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy in the preservice elementary school teachers in Ontario. For this type of analysis independent groups need to be determined.

***Determining the high, average, and low groups.*** To run these ANOVAs, independent groups needed to be established for each of the constructs. Considering the sample population was comprised of preservice elementary school teachers who have completed an undergraduate degree as a requirement for their program, it is arguable that their levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy would be different than that of the population in other studies using the general population (mathematics anxiety) or in-service teachers (mathematics anxiety and mathematics teaching anxiety). Because of this differentiation the low, average, and high levels for each construct were computed by having the low population indicated by individuals who scored less than one standard deviation below the mean, the high population indicated by individuals who scored higher than one standard deviation above the

mean, and the average population being those with scores within one standard deviation below and above the population mean. This method of separating the population is beneficial as it generates the three independent groups required, but the caveat is that the high, average, and low groups are therefore in relation to the rest of the group. This may hurt the generalizability of the results but appropriate scores for these groups were not found in the literature. The following is a look at the analysis for each of the instruments.

*High, average, and low groups for the RMARS.* The RMARS is comprised of 25 Likert scale items each with responses ranging from 1-5. This gives a possible lowest score of 25 and highest score of 125. The participants had a mean RMARS score of 71.42 with a standard deviation of 24.90. Table 9 and Figure 7 give the results gathered from determining the groups for the RMARS.

Table 9

*RMARS Categorical Results*

| **Group** | **n** | **Range of Score** |
|---|---|---|
| Low Anxiety | 30 | $x \leq 39$ |
| Average Anxiety | 116 | $46 < x < 96$ |
| High Anxiety | 39 | $x \geq 96$ |

The shaded area in Figure 7 represents the score of an average level of mathematics anxiety whereas the area to the left of the shaded area represents the score for low mathematics anxiety and the area to the right of the shaded area represents the score for high mathematics anxiety.

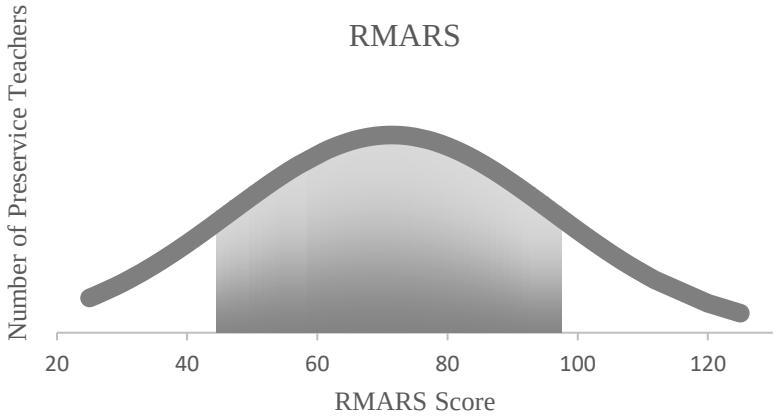


*Figure 7.* RMARS distribution.

*High, average, and low groups for the TCHAS.* The TCAHS is comprised of 25 Likert scale items each with responses ranging from 1-5. This gives a possible lowest score of 25 and highest score of 125. The participants had a mean TCHAS score of 73.72 with a standard deviation of 15.39. Table 10 and Figure 8 give the results gathered from determining the groups for the TCAHS.

Table 10

*TCHAS Categorical Results*

| **Group** | **N** | **Range of Score** |
|---|---|---|
| Low Anxiety | 32 | $x \leq 58$ |
| Average Anxiety | 122 | $58 < x < 89$ |
| High Anxiety | 31 | $x \geq 89$ |

The shaded area in Figure 8 represents the score for an average level of mathematics anxiety whereas the area to the left of the shaded area represents the score for low mathematics

teaching anxiety and the area to the right of the shaded area represents the score for high mathematics teaching anxiety.

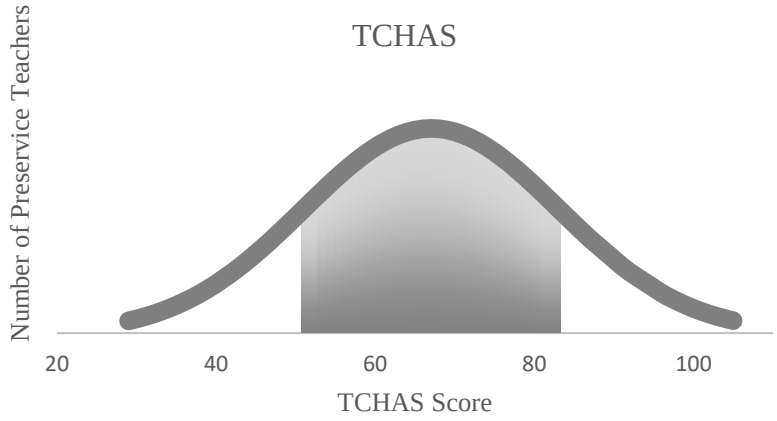


*Figure 8*. TCHAS distribution.

*High, average, and low groups for the TSES.* The TSES is comprised of 12 Likert scale items each with responses ranging from 1-9. This gives a possible lowest score of 12 and highest score of 108. The participants had a mean TSES score of 81.21 with a standard deviation of 14.42. Table 11 and Figure 9 give the results gathered from determining the groups for the TSES.

Table 11

*TSES Categorical Results*

| **Group** | **n** | **Range of Score** |
|---|---|---|
| Low Efficacy | 34 | $x \leq 67$ |
| Average Efficacy | 122 | $67 < x < 95$ |
| High Efficacy | 31 | $x \geq 95$ |

The shaded area in Figure 9 represent the score for an average level of mathematics anxiety whereas the area to the left of the shaded area represents the score for low mathematics teacher efficacy and the area to the right of the shaded area represents the score for high mathematics teacher efficacy.

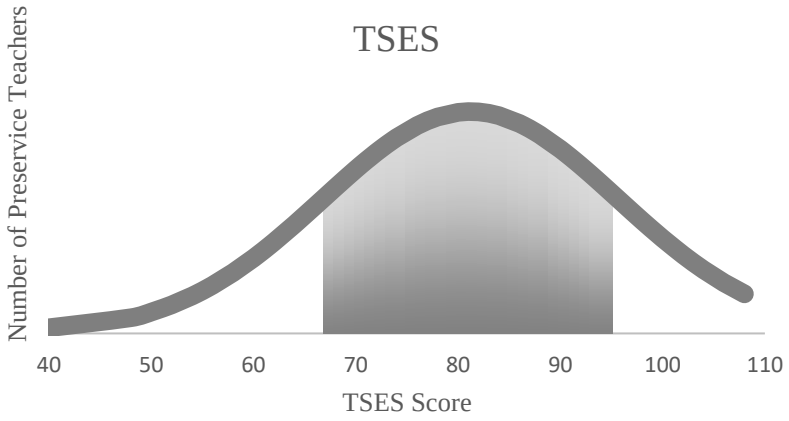


*Figure 9.* - TSES distribution.

Using the above calculations, the categories of low, average, and high were determined for all three of the constructs. With these categories computed the ANOVAs could now be performed.

Multiple analysis of variances (ANOVAs) were computed to examine the relationship between the three instruments: RMARS, TCHAS, and TSES. Multiple separate ANOVAs were computed instead of a 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 studies in univariate contexts. The research for this dissertation is exploratory in nature—looking to explore the relationship amongst the three constructs. Also, in previous research, these three constructs have been examined in a univariate context. In other words, prior research has examined the constructs in pairs, but no research has examined all three constructs together. Therefore, three separate ANOVAs were run. These three ANOVAs looked at the relationship between the scores from the RMARS and the TCHAS, the relationship of the scores from the TCHAS and TSES, and finally the relationship of the scores from the TSES and RMARS.

***RMARS – TCHAS ANOVA.*** An ANOVA was conducted to determine 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). For the ANOVA, the Gabriel procedure was used as a post-hoc test because sample sizes are different between the three groups. The initial results from the ANOVA are shown in Table 12.

Table 12

*RMARS – TCHAS ANOVA Analysis Results*

| **Source** | ***df*** | ***SS*** | ***MS*** | ***F*** | ***p*** |
|---|---|---|---|---|---|
| Between groups | 2 | 16,968.58 | 8484.29 | 57.99 | .000 |
| Within groups | 182 | 26,624.36 | 146.288 | | |
| Total | 184 | 43,592.94 | | | |

The first part of this analysis to notice is the high F-value. This high F-value indicates that there is a substantial cause to reject the null hypothesis of an ANOVA that our samples have identical means. That is to say, the variance between the groups is caused primarily by the

difference in the means as opposed to the variation within the means. This result comes as no surprise considering the groups were shown to be negatively correlated and the groups were created based on their average scores.

Keeping in mind the high F-value, the ANOVA showed a significant effect of mathematics anxiety on an individual's levels of mathematics teaching anxiety. Specifically, individuals with low mathematics anxiety had significantly lower mathematics teaching anxiety than those with average mathematics anxiety ($p < .01$) and high mathematics anxiety ($p < .01$). Additionally, individuals with average mathematics anxiety had significantly ($p < .01$) lower levels of mathematics teaching anxiety than those with high mathematics anxiety. These results are in line with the current literature on the relationship between mathematics anxiety and mathematics teaching anxiety (Adeyemi, 2015; Haciomeroglu, 2014; Peker & Ertekin, 2011; Unlu, Ertekin, & Dilmac, 2017; Hadley & Dorward, 2011).

***TSES – TCHAS ANOVA.*** An ANOVA was completed to determine if there was a significant difference between an individual's scores based on their levels of mathematics teacher efficacy (TSES) and their level of mathematics teaching anxiety (TCHAS). For the ANOVA, the Gabriel procedure was used as a post-hoc test because sample sizes are different between the three groups. The results from the ANOVA are shown in Table 13.

Again, make note of the high F-value. As above, this indicates that there is a substantial cause to reject the null hypothesis of an ANOVA test that our samples have identical means. That is to say, the variance between the groups is caused primarily by the difference in the means as opposed to the variation within the means.

Table 13

*TSES – TCHAS ANOVA Analysis Results*

| **Source** | ***df*** | ***SS*** | ***MS*** | ***F*** | ***p*** |
|---|---|---|---|---|---|
| Between groups | 2 | 6,265.66 | 3,132.83 | 15.275 | .000 |
| Within groups | 182 | 37,327.28 | 205.10 | | |
| Total | 184 | 43,592.94 | | | |

Keeping in mind the high F-value, the ANOVA showed a significant effect of mathematics teacher efficacy on an individual's levels of mathematics teaching anxiety. Specifically, individuals with low mathematics teacher efficacy had significantly higher mathematics teaching anxiety than those with average mathematics teacher efficacy ($p < .01$) and high mathematics teacher efficacy ($p < .01$). Additionally, individuals with average mathematics teacher efficacy had significantly ($p < .01$) higher levels of mathematics teaching anxiety than those with high mathematics teacher efficacy. These results are in line with the current literature surrounding mathematics teacher efficacy and mathematics anxiety (Peker, 2016).

***RMARS – TSES ANOVA.*** An ANOVA was performed to determine if there was a significant difference between an individual's scores based on their level of mathematics anxiety (RMARS) and their level of mathematics teacher efficacy (TSES). For the ANOVA, the Gabriel procedure was used as a post-hoc test because sample sizes are different between the three groups. The results from the ANOVA are shown in Table 14.

The ANOVA showed a significant difference in mathematics teacher efficacy scores amongst individuals with low levels of mathematics anxiety and those with average levels of mathematics anxiety ($p < .05$), but no significant difference elsewhere. Interestingly, the

individuals who are 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. This result is not in line with what current literature says regarding mathematics anxiety and mathematics teaching anxiety, that mathematics anxiety and mathematics teacher efficacy are negatively correlated (Gresham, 2008; Swars, Daane, & Giesen, 2006). This will be discussed further in subsequent chapters.

Table 14

*RMARS – TSES ANOVA Analysis Results*

| **Source** | ***df*** | ***SS*** | ***MS*** | ***F*** | ***p*** |
|---|---|---|---|---|---|
| Between groups | 2 | 1,394.915 | 697.458 | 3.441 | .034 |
| Within groups | 182 | 36,887.863 | 202.681 | | |
| Total | 184 | 38,282.778 | | | |

## 4.2 Results from Qualitative Analyses

Results from the qualitative analyses focus on the data collected from the 16 interviews with preservice teachers. For the analyses, interviews were separated again into bins based on their questionnaire results (Table 15). As this research examines the relationships between the constructs, interviews in a high or low bin for one construct were coded once looking for instances of one of the other two constructs and then once again to look for instances of the last remaining construct. For example, of the 16 interviewees, two were categorized as having high mathematics anxiety. These two interviews were coded together once looking for instances of mathematics teaching anxiety and then coded again separately looking for instances of mathematics teacher efficacy. Each round of coding started from scratch and yielded unique codes related to the lens of a specific construct. This categorization allowed for interviewees to

Table 15

*Themes Generated from Qualitative Analysis*

| | Mathematics Anxiety Lens | Mathematics Teaching Anxiety Lens | Mathematics Teacher Efficacy Lens |
|---|---|---|---|
| **High Mathematics Anxiety Bin** | | Developing Strategies to Cope<br><br>High Mathematics Anxiety Pushing Teaching Practice Higher | Pushing Through Anxiety<br><br>Using Momentum |
| **Low Mathematics Anxiety Bin** | | Relation to Peers<br><br>Bringing the Passion | No Themes Found |
| **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<br><br>Taught One Way, Asked to Teach Another | Comfortability with Mathematics | |
| **Average Bin** | Always Growing and Learning with Students<br>Learning from their Teacher Education<br>Dislike for Higher Level Mathematics | | |

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 average bin, this method of coding could not be used as the interviews in this bin were neither high nor low. For this bin, the seven interviews were coded once using emergent coding without any lens of a construct. The themes generated from this analysis can be seen in Table 15.

#### 4.2.1 High mathematics anxiety and mathematics teaching anxiety.

Two themes emerged from the coding of the two interviews in relationship with mathematics teaching anxiety. These themes were *developing strategies to cope* and *mathematics anxiety pushing their teaching practice higher.*

***Developing strategies to cope.*** The preservice teachers with high mathematics anxiety know they struggle and get anxious about mathematics. When they approach the idea of teaching mathematics, they develop pedagogical strategies to deal with this anxiety that help them teach effectively. For example, one preservice teacher found it effective to break down the mathematics lesson into smaller and more digestible chunks than their peers. They found that helped them digest the mathematics and allowed them to teach mathematics more effectively. Another preservice teacher found it effective to break the lesson down into easier terms. The preservice teacher indicated this helped them understand the content more efficiently leading to them giving better instruction and their students understanding the content better as well:

> We say you have to put it into P/J standard. So, we were talking about fractions, decimals, and percentages yesterday. If you put it into something, they can understand…so drawing a pizza and eating a quarter of a pizza, that kind of thing. So, making it simple enough so they can understand, but even if you are having issues with it this is a way around it. (Erin, interview)

Preservice teachers also talked about their ability to find effective teaching resources. The helpful resources varied by author, by medium (e.g. books, online resources, classroom technology, etc.) and by source (e.g. colleagues, instructors, associate teachers, etc.) and helped reduce the amount of anxiety that these preservice teachers felt about teaching mathematics. When asked about what advice or help the preservice teachers would give a fellow preservice teacher who is struggling with mathematics teaching anxiety, one preservice teacher said:

> I would give them some of the resources I have. That is one of the things that I found really helpful. At first it seems like a lot. My teacher gave me a boat load of resources and then once I had the time to sit through it and wade through [them] I realized that there was a lot at my disposal and I didn't have to come up with everything myself and that quelled my anxiety to teach. (Shelly, interview)

Although these preservice teachers struggled with high levels of mathematics anxiety, they took the steps necessary to improve themselves and subdue their mathematics teaching anxiety. Instead of shying away from teaching mathematics these preservice teachers understood that they were expected to teach mathematics and they did what they could to make this as easy as possible.

***High mathematics anxiety pushing their teaching practice higher.*** Preservice teachers indicated that mathematics anxiety was a topic that was discussed in their mathematics education courses and preservice teachers described being aware of their own relationship with mathematics and the potential impact this may have on their students. Because of this awareness, preservice teachers with high mathematics anxiety worked more intently to improve their teaching practice by working on their mathematical content knowledge as well as their pedagogical content knowledge. Preservice teachers talked about making the appropriate steps to

ensure they engaged in effective teaching practices. One preservice teacher discussed being anxious to teach mathematics in their upcoming placement. When asked how they dealt with these feelings they replied, “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” (Shelly, interview). This initial anxiety to teach mathematics pushed them to work harder and ensure they were capable.

Additionally, there were accounts of preservice teachers struggling with mathematics as an elementary or secondary student. In the eyes of these preservice teachers this struggle ended up being a benefit to their teaching practice. There were frequent accounts of preservice teachers expressing they were able to relate to the students and understand students’ struggles with mathematics because of their own struggles with mathematics when they were an elementary or secondary student. One preservice teacher discussed how their struggle with mathematics was a benefit to their teaching practice and to their students:

> Basically, I struggled with angles in school. That was always one of my biggest issues was angles. That was about grade six. That was probably one of the points when I never really got it. So, knowing how much I struggled with that makes me sit down and work through things with my grade fives to make sure they understand it. (Erin, interview)

Preservice teachers also discussed that the benefits of being able to show your struggles to the students and the benefits of being able to work through the problem *with* the students:

> I think I have the patience to sit down and work through it with them. I wouldn’t just give them the answer because I don’t necessarily know the answer right off the bat. So, I have to sit down and work through the problem with them instead of going “you have had enough time.” (Erin, interview)

These examples shed light on a possible disassociation between mathematics anxiety and mathematics teaching anxiety. It appeared that the preservice teachers were aware of their anxiety towards mathematics, but they also believed there was a disconnect between mathematical content knowledge and mathematics pedagogical knowledge. That is to say, the preservice teachers were aware of their apprehension towards mathematics, but they believed their ability to teach could be separated from their personal feelings towards mathematics. When asked if they believed they need to be a good mathematics student in order to be a good mathematics teacher, the preservice teachers with high mathematics anxiety replied with "I didn't get a degree in math by any means, but I am certainly able to teach elementary school math" (Erin, interview) and "you don't have to be a math wiz to teach math. You just have to understand whatever content you are teaching" (Shelly, interview). The preservice teachers pushed themselves to improve their teaching practice and sometimes used their prior struggles with mathematics as a benefit to their teaching practice.

#### 4.2.2 High mathematics anxiety and mathematics teacher efficacy.

Two themes emerged from the coding of these two interviews in relationship with mathematics teacher efficacy. These codes were *pushing through the anxiety* and *using momentum*.

***Pushing through the anxiety.*** The preservice teachers with mathematics anxiety knew they had a negative or poor mindset towards mathematics, but they also knew the importance of modelling a positive mathematical mindset. These preservice teachers believed that even though they had a negative mathematics experience, it did not have to be the same for their future students. When asked how they thought their personal attitude towards mathematics will affect their students one preservice teacher responded with "I know that by modelling a positive attitude it will be picked up the same way as modelling a negative attitude" (Shelly, interview).

Furthermore, this preservice teacher added “their behaviour will be similar to mine and even if they are not the best at math and even if they didn’t enjoy that particular thing they will try”.

This instance provides an example for preservice teachers having mathematics anxiety but still believing they have the capabilities to impact their students positively in the mathematics classroom speaks to the preservice teachers’ mathematics teacher efficacy.

***Using momentum.*** There were consistent mentions of the preservice teachers being initially anxious to teach mathematics, but eventually “getting the hang of it” (Erin, interview). One preservice teacher described an instance where they got moved mid-placement from a grade one classroom to a grade five classroom: “then I got into grade five and went ‘oh crap!’, but now I don’t feel too bad teaching math” (Erin, interview). Another teacher talked about asking their associate teacher for the opportunity to teach mathematics in their final placement because they still had not had a chance to teach the subject. They go on to mention, “then I panicked for a little bit because I didn’t know how to teach it or what I really needed to prep (Shelly, interview)”. They later described, “but by the end of the first week I got that out and I sorted myself out”.

The preservice teachers indicated that these initial feelings of anxiety to teach mathematics were eventually tempered by successful teaching experiences. The preservice teachers often gave credit to their associate teachers and the instructors of their mathematics teaching courses for helping them push through.

#### 4.2.3 Low mathematics anxiety and mathematics teaching anxiety.

Two themes emerged from the coding of the two interviews in relation to mathematics teaching anxiety. These themes were *relation to their peers* and *bringing the passion*.

***Relation to their peers.*** The preservice teachers interviewed talked about mathematics teaching anxiety and mathematics anxiety on a scale or scope larger than themselves. Both

preservice teachers who had levels of low mathematics anxiety talked about feeling an increased level of confidence to teach mathematics relative to their peers in their program. One preservice teacher described their mathematics curriculum course being set up such that each table had a mix of high, average, and low mathematically anxious individuals. They go on to say:

> So, I was working right with somebody twice a week who had zero comfortability with math and the knowledge wasn't there. I think a lot of it comes from not really learning it very well while they were going through school and just kind of getting through it and then not doing anything with it in their adult life. Now when they are in a professional course and something even like grade three fractions are coming and they don't know how to teach it, but they feel like they should know how to teach it, but they don't. (John, interview)

Another preservice teacher described their ability as a mathematician when they were younger compared to their peers: "I was really advanced, and I have a hard time saying that compared to my counterparts (Riley, interview)". They go on to add that, "I am much more confident and better at math than a lot of my colleagues." This comparison of mathematics ability and mathematics teaching ability to their peers could have an impact on the preservice teachers' mathematics teaching anxiety. 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.*** Both preservice teachers who were interviewed talked about their passion for mathematics. They discussed the use and benefits of mathematics in their daily lives and a general lack of enthusiasm for mathematics they saw in their elementary classrooms.

Specifically, one preservice teacher described their relationship with mathematics and how they teach the subject:

> The kids know how much I love math, I can tell you that much. I don't care what it is…when I meet a stranger and they tell me about a passion that I know nothing about…sometimes enthusiasm is contagious. That is me with math. (Riley, interview)

A second preservice teacher spoke similarly about using their passion for mathematics to bolster students who are strong in mathematics but have reservations about expressing their strength:

> I have always been told that passion is contagious. I am hoping that the students that are good and comfortable with math will feel confident with math. They will want to participate, and I hope I bring that passion out of them. (John, interview)

Both preservice teachers leveraged their low mathematics anxiety and overall comfortability and passion for mathematics to bolster their mathematics teaching capabilities. They feel that they can bring that extra piece that is missing from other elementary school teachers in the elementary classroom.

**4.2.4 Low mathematics anxiety and mathematics teacher efficacy.** Interestingly, amongst the two preservice teachers interviewed with low mathematics anxiety there were no overarching themes consistent between the two in relationship with mathematics teacher efficacy. Both preservice teachers had vastly different experiences with mathematics teacher efficacy.

One preservice teacher had varying levels of mathematics teacher efficacy when they talked about their teaching experience. The preservice teacher consistently discussed how their low levels of mathematics anxiety were a hinderance to their teaching practice:

> 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 is 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. (John, interview)

This preservice teacher later talks again about their confidence with mathematics being a hinderance to their teaching:

> So, understanding people's different ways of thinking and problem solving through something was a big thing that I have taken away over the last couple of years and like I mentioned before—having to slow down and make sure that people are following when I am teaching math, as opposed to nodding through it and getting lost is a big takeaway from the last couple of years. (John, interview)

For this preservice teacher, their mathematics teacher efficacy was lowered by their low levels of mathematics anxiety. This was not the same for the second preservice teacher who also had low levels of mathematics anxiety.

The second preservice teacher who was interviewed described their positive relationship with mathematics as a leverage point for the effective teaching practice. They discussed how they felt confident teaching mathematics before any formal teacher training:

> I found out that most of what I am doing aligns with current research. I don't have to change anything. The way I am teaching math and the way that I approach math and the way that I feel about math is already successful, the kids are benefiting. (Riley, interview)

This preservice teacher often talked about their comfortability with mathematics being beneficial. The preservice teacher talked about focusing on a topic of interest of an elementary student and using mathematical knowledge to intertwine mathematics into the elementary

student's area of interest to make mathematics more interesting for the elementary student.

These two preservice teachers seem to have had two very different lived experiences in terms of their mathematics teacher efficacy. These differences in experiences shows how personal mathematics anxiety, teaching anxiety, and teacher efficacy can be experienced and sheds light on the results from the quantitative analyses that show small to no correlations between mathematics anxiety and mathematics teacher efficacy.

**4.2.5 High mathematics teaching anxiety and mathematics anxiety.** One theme was found across both preservice teachers with high mathematics teaching anxiety who were interviewed in relation to mathematics anxiety. This theme was *good student, poor student experience.*

***Good student, poor student experience.*** When the preservice teachers were asked about their experience as an elementary or secondary student with mathematics, both preservice teachers discussed that mathematics was a subject they enjoyed. One preservice teacher replied, "I am fine with mathematics" and "I liked mathematics in general" (Mel, interview) while the other preservice teacher answered, "I always really liked it, especially in elementary school and high school" (Shelly, interview). Both preservice teachers talked about overcoming struggles and succeeding with mathematics. This was not expected as both preservice teachers were categorized as having high mathematics teaching anxiety.

Interestingly though, when both preservice teachers were asked to describe what they thought contributed to their personal relationship with mathematics, they described instances of poor experiences with teachers, classrooms, and school management. One preservice teacher passionately talked about a high school teacher telling them "you shouldn't take math anymore" (Mel, interview). The preservice teacher talked at length about how this experience stayed with

them and the challenge it was to fight through the experience.

The other preservice teacher talked about having a teacher that "gave off the 'I don't like math and we are only doing this because we have to' sort of vibe" (Shelly, interview) and how this preservice teacher's prior success as a high school student caused them to receive little attention and support from their mathematics teacher because they were "going to get a B regardless". This preservice teacher also talked about having to take a high-level high school mathematics course online because their school did not offer the course. They talked about the negative experience this had on them as a mathematics student.

The emergence of this theme was unexpected as research has shown that an individual who had a poor experience with mathematics as a student would likely have a negative attitude towards mathematics an adult (Norwood, 1994), but both preservice teachers expressed having a good personal relationship with mathematics. Additionally, with a good personal experience with mathematics it is surprising that these preservice teachers would have high mathematics teaching anxiety. This manifestation of high mathematics teaching anxiety despite a positive relationship with mathematics might be caused by the preservice teachers' unwillingness to be a bad teacher like the one they remember from when they were students. This could be a drive and subsequently cause anxiety because the preservice teachers have experienced what it is like to be challenged by a poor mathematics teacher and they do not want their students to experience what they went through as elementary and secondary school students.

#### 4.2.6 High mathematics teaching anxiety and mathematics teacher efficacy.

One theme emerged from the interviews given by the two preservice teachers with high mathematics teaching anxiety in relation to mathematics teacher efficacy. This theme was a *reliance on resources*.

***Reliance on resources.*** Both preservice teachers that were interviewed had different experiences when talking about their mathematics teacher efficacy. One preservice teacher focused on their concern about being able to meet the needs of all the students in their elementary classroom while the other discussed the struggle of keeping up with mathematics content. Interestingly, when asked what advice they would give a colleague who is struggling with teaching mathematics both preservice teachers talked about their reliance on resources to help quell their own mathematics teaching anxiety and increase their teacher efficacy. One preservice teacher talked about a specific resource and the benefits they received from looking at the effective strategies for teaching mathematics that were outlined in the resource. As seen earlier, another described the benefit they received from their collection of resources as a whole

It appears that the preservice teachers interviewed with high mathematics teaching anxiety also worry about their teaching practice and find benefit in leveraging the resources available to them. The resources offer strategies and teaching practices that have already been proven as effective for their own teaching practice with little initial effort. This also fits the theme found of *developing strategies to cope* that is found in preservice teachers with high mathematics anxiety.

#### 4.2.7 Low mathematics teaching anxiety and mathematics anxiety.

One theme was found amongst the four preservice teachers interviewed with low mathematics teaching anxiety in relation to mathematics anxiety. This theme was a focus on *mathematical content knowledge*.

***Mathematical content knowledge.*** When asked to describe their personal relationship with mathematics, all four of the preservice teachers discussed either little struggle with mathematics or enjoyment of mathematics as a student. Interestingly, when asked questions relating to their experiences or the experiences of their peers teaching mathematics there was a

constant focus on mathematical content knowledge. Some of the experiences surrounded the positive correlation between teaching mathematics and mathematics content knowledge, such as "I think the better you do academically in math, the better you will be at teaching math overall" (Riley, interview), but some stressed a negative correlation between teaching mathematics and mathematical content knowledge. For example: "I would say you almost have to wipe everything you have ever learned and relearn it the way that students are learning it" (Eve, interview), "yeah, I definitely think it put me at a disadvantage just in terms of my effectiveness as a teacher. I could teach math always, but my effectiveness wasn't as good as it could be with me going into it being such a proficient mathematician" (Mike, interview), and:

> I think it is something I have battled with these past couple of years with the fact that I have always been so proficient in math. I have to take a step back and look at it and be like "hey, not everyone is proficient in math and I need to be ready for the fact that not all of these kids are going to get it with the one explanation that I have." So, I have to come up with three to four strategies to solve this. (John, interview)

Although some preservice teachers talked about content knowledge as being bad for their teaching while some talked about content knowledge being beneficial for their teaching it is interesting to note that each preservice teacher related their mathematical teaching to their mathematical content knowledge.

When discussing strategies that other teachers could use to overcome mathematics anxiety and mathematics teaching anxiety the focus was again on mathematical content knowledge. Examples include: "my advice would be either to find a tutor or get some YouTube tutorials and just expose yourself to it and try to work through it" (John, interview) and "look at the most difficult grade you will be teaching. If you are in primary and junior, look at grade six.

If you can understand everything in grade six you are fine all the way down the ladder" (Riley, interview). Even when giving advice to peers the focus was on mathematical content knowledge first and then pedagogy.

This theme could be related to the overall positive experience these preservice teachers had with mathematics as a student. The preservice teachers with low mathematics teaching anxiety did not have the stresses of low mathematical content knowledge and they used their comfortability with mathematics as a focal point for their teaching. These preservice teachers believed that their peers could benefit and improve their teaching by building their content knowledge first, allowing them to expand their pedagogy as a result.

**4.2.8 Low mathematics teaching anxiety and mathematics teacher efficacy.** One theme emerged from the coding of the preservice teachers with low mathematics teaching anxiety in relation with mathematics teacher efficacy. This theme was *overcoming early teaching obstacles*.

***Overcoming early teaching obstacles.*** All four preservice teachers interviewed with low mathematics teaching anxiety mentioned struggling with teaching early in their preservice teaching career but working through this challenge and overcoming the obstacle. All four also described the struggle or obstacle as rooted in pedagogical practices rather than mathematical content as the barrier. For example, one preservice teacher talked about their initial struggle with teaching mathematics coming from exposure to the magnitude of teaching tools, resources, and best teaching practices that were taught in their curriculum course. This preservice teacher quickly realized on their following placement that while the different teaching tools, resources, and practices are useful, they did not all have to be implemented at once, especially for a beginning teacher. Another preservice teacher talked about struggling to keep the students

engaged with mathematics and the challenge of being able to reach all of their students. They described how this struggle was met by an “ah-ha” moment early in their teaching experience and their efficacy quickly growing afterwards.

These moments of early struggle and subsequently overcoming this struggle demonstrates a link between efficacy and anxiety. All the preservice teachers with low mathematics teaching anxiety had either high or average mathematics teacher efficacy and consistently mentioned experiences that highlighted highly efficacious behaviours. These higher levels of teacher efficacy helped them overcome obstacles and prevent the feelings of anxiety from rising. When an obstacle arose, the preservice teachers had the belief in themselves as future teachers to enable them to work through the challenge. Colleagues with low mathematics teacher efficacy may stress, worry, and dwell on these obstacles because they are not sure if they can overcome them leading to higher levels of mathematics teaching anxiety.

**4.2.9 High mathematics teacher efficacy and mathematics teaching anxiety.** When looking through the lens of mathematics teaching anxiety, one theme emerged from the interviews with preservice teachers with high mathematics teacher efficacy. This theme was *overcoming early teaching obstacles*. This is the same theme as above, because the two individuals with high levels of mathematics teacher efficacy also had low levels of mathematics teaching anxiety and were half of the population from the low mathematics teaching anxiety and its relationship with mathematics teacher efficacy category. For brevity, the *overcoming obstacles* theme will not be discussed here as it can be read above in detail.

**4.2.10 High mathematics teacher efficacy and mathematics anxiety.** When looking through the lens of mathematics anxiety, one theme emerged from the interviews of the two preservice teachers. This theme was an overall *enjoyment of mathematics*.

***Enjoyment of mathematics.*** It has been shown that preservice teachers with high levels of mathematics teacher efficacy have lower levels of mathematics anxiety (Gresham, 2008; Swars, Daane, & Giesen, 2006). Both preservice teachers discussed enjoying mathematics as a student and having favourable experiences as a student. For example, one preservice teacher discussed how mathematics was has "always been a strong point" and "something that came naturally" (Mike, interview) to them. Interestingly, the second preservice teacher described how mathematics is still something they had to work at, but they enjoyed the work and still enjoyed mathematics:

> In elementary school I didn't have to work hard at it at all but as I got older through high school it was definitely something I had to work at but I really enjoyed it so I never minded that. (Eve, interview)

This enjoyment of mathematics paired with a high level of mathematics teacher efficacy aligns with the expectations of mathematics teacher efficacy and mathematics anxiety (Gresham, 2008; Swars, Daane, & Giesen, 2006; Unlu, Ertekin & Dilmac, 2017). That is, that high mathematics teacher efficacy is correlated to low levels of mathematics anxiety. If mathematics is an approachable subject for the preservice teachers, then they are more likely to approach teaching mathematics and believe in their ability to reach their students and effectively teach the subject material. Being able to comfortably rely on mathematical content knowledge to supplement their mathematical teaching practice boosts the preservice teachers' levels of mathematics teacher efficacy.

**4.2.11 Low mathematics teacher efficacy and mathematics teaching anxiety.** When looking through a lens of mathematics teaching anxiety, one theme emerged from the interviews with the four preservice teachers with low mathematics teacher efficacy. The theme was *small*

*scale confident, large scale worried.*

***Small scale confident, large scale worried.*** It was interesting to see that only one of the four preservice teachers in this category had high mathematics teaching anxiety according to their survey results. The others had either average or low mathematics teaching anxiety. The responses from the preservice teachers reflected these scores. Three of the four preservice teachers indicated that their concerns about their teaching practice were holistic or large-scale concerns. The one preservice teacher who did not indicate these types of concerns was categorized as having high levels of mathematics anxiety and their concerns stemmed mainly from content knowledge. The remainder of the discussion surrounding the theme *small scale confident, large scale worried* will focus on the three preservice teachers with average or low mathematics teaching anxiety.

These holistic and larger scale concerns focused on the preservice teachers' ability or inability to impact all their students in their elementary classroom. The preservice teachers talked about their worry of reverting to teaching the way they were taught as elementary or high school students and how this method of teaching may work for some of the preservice teachers' future elementary students, but not for all. For example, one preservice teacher talked about how they are a visual learner and how this would impact their long-term teaching practice:

> I am a visual learner, meaning I look at something, I read it, and I understand it. I am going to like the students who are visual learners. So whatever learning style that I have, I am going to go about it. So, whatever the way I learn I am going to go about teaching in a very similar fashion. So, the majority of it is going to be very academic. Read the question, answer it, and parts of my lesson may be 25% - 30% less academic. Maybe a little bit more hands on and stuff like that. It is just the nature of it. I think throughout my

> career as a teacher, in-service teacher, I will have to really work on that to change so that the way that I teach will not be the same way that I was taught. Nevertheless, the moment of feeling stressed and I start feeling anxiety I know for a fact that I will go right back in my shell. I will teach it the same way I was taught. (Ryan, interview)

The preservice teachers who have low mathematics teacher efficacy focused on the long-term impact of helping their students learn mathematics, not the day-to-day stresses of teaching the class and getting through the teaching day or that particular lesson.

Another preservice teacher talked about how their struggle was not the teaching of mathematics to an individual student but rather being able to teach an entire class with a variety of different learners. When asked what made them nervous about teaching mathematics the preservice teacher didn't describe a difficulty with content, rather it was "feeling like there is this pressure to reach every student" and "the other part that makes me nervous is how to engage all the learners" (Mel, interview). This same preservice teacher, when asked about how their view of mathematics has changed over the course of their teaching degree, indicated that their change in view wasn't content specific, for example, the difficulty of teaching fractions, or how to use manipulatives properly, instead it was the realization of "how much differentiation is needed" (Mel, interview). This again highlights the concern these preservice teachers have for the larger issues of teaching mathematics as opposed to the smaller day-to-day issues and struggle with preservice teaching.

This notion of low mathematics teacher efficacy being detached from mathematical content knowledge and instead focused on larger pedagogical issues is consistent amongst the majority of preservice teachers interviewed. This could explain the disconnect found between mathematics anxiety and mathematics teacher efficacy, as the downfall in mathematics teacher

efficacy isn't focused primarily on a lack mathematics content, rather it is focused on the larger issues of teaching mathematics such as proper pedagogy and differentiation in their elementary mathematics classroom. This will be discussed further in the following chapter.

***Taught one way, asked to teach another.*** As described earlier, the majority of the preservice teachers in this category have little to no problem with mathematics. In fact, the preservice teachers described their relationship with mathematics as "we get along just fine" (Ryan, interview) or "I would say that I like math" (Rachael, interview). When asked about their experience with mathematics as a student they talked about the way they were taught as being very traditional. That is to say, very structured and following the typical worksheet, drill and kill, style of teaching. The preservice teachers here made mention of this teaching style not being the ideal teaching style for mathematics, but as a teaching style that worked for them and that they excelled at. This is not surprising as the teacher education program in Ontario is a graduate degree program, meaning the preservice teachers have an undergraduate degree and are likely products of a type of school system that focuses on memorization, worksheet, and a drill and kill mentality. These preservice teachers are naturally *good at being a student* and although they may have struggled at some points during their student career, they eventually succeeded in an educational system that was most likely a traditional post-secondary lecture style education system.

The struggles brought up by preservice teachers with low mathematics teacher efficacy focused on having to change their teaching methodology. These preservice teachers are now being asked to teach in a way that they were not taught, and this is causing disconcert. One preservice teacher describes this disassociation:

I don't know when this new math started but I certainly never had manipulatives and that

> stuff in my math. We learned by wrote memorization and by repetition 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 that way I learned. So, trying to teach kids to learn in a way that I never learned is mindboggling. (Mel, interview)

We see here the disassociation between the preservice teacher's experience as a student of mathematics and their experiences now as a teacher of mathematics. This seems to be a focus surrounding their lack of mathematics teacher efficacy.

As described above in the *small scale confident, large scale worried* theme, we see that preservice teachers were also worried that they will fall back into a teaching style they are comfortable with as soon as they come across adversity. For instance, one preservice teacher noted that, "nevertheless, the moment of feeling stressed and start feeling anxiety I know for a fact that I will go right back in my shell. I will teach it the same way I was taught" (Ryan, interview) and another preservice teachers mentioned, "I feel that as much as I am learning these other ways of doing something I feel like there is always a chance that I will stick to what I know best and how I learned best" (Rachael, interview).

The cases of preservice teachers being worried about their teaching style has a silver lining; the preservice teachers are being critical of their teaching practice and are showing concern for their pedagogy. Unfortunately, this concern is causing lower mathematical teacher efficacy. The preservice teachers were aware of the effort that needs to be put into teaching mathematics effectively and this caused concern and ultimately lowered the preservice teachers' mathematics teacher efficacy.

**4.2.12 Low mathematics teacher efficacy and mathematics anxiety.** The interviews given by the four preservice teachers who were categorized as having low mathematics teacher efficacy (according to their results from the survey) were isolated and reread looking for relations to mathematics anxiety. These interviews were coded using emergent coding and these codes were further grouped into themes. Four preservice teachers with low mathematics teacher efficacy were interviewed and one major theme emerged. This theme was *comfortability with mathematics.*

***Comfortability with mathematics.*** Of the four preservice teachers in this category, only one of them indicated they had a negative experience with mathematics and high levels of mathematics anxiety (based on their survey results). Furthermore, when asked about their personal relationship with mathematics as a student, the other three preservice teachers responded with "I like math in general" (Mel, interview), "I would say that I like math" (Rachael, interview), and "we got along just fine" (Ryan, interview). These results are contradictory to the correlation of low mathematics teacher efficacy with high mathematics anxiety (Gresham, 2008, Swars, Daane, & Giesen, 2006; Unlu, Ertekin, & Dilmac, 2017) and points towards a possibility of other interactions between mathematics and teaching mathematics happening in the background.

These three preservice teachers talked about their ability to manipulate mathematics individually and help a student one-on-one, but similar to the theme above, it seems these preservice teachers struggled with the ability to fully meet the needs of all of their students on a long-term basis. Again, on a smaller scale these preservice teachers showed signs of being highly efficacious in their mathematical ability and having little to no mathematics anxiety, but when asked about their teaching ability they switch their focus to the larger scale issues of teaching

mathematics such as best teaching practices and differentiated instruction.

**4.2.13 The typical student.** In the interviews given by the seven preservice teachers who were categorized as having average mathematics anxiety, average mathematics teaching anxiety, and average mathematics teacher efficacy (according to their results from the survey) three themes were found. These themes were *always growing and learning with the students*, *learning from their teacher education,* and *a dislike for higher level mathematics.*

***Always growing and learning with the students.*** All of the preservice teachers interviewed discussed the constant and future learning they will need to do to be an effective mathematics teacher. They mentioned the importance of putting the time and effort into improving their mathematics teaching and mathematics content knowledge. When describing a learning experience during an in-class placement, one preservice teacher said "I realized that I am always going to be a student. I am never going to stop learning" (Beth, interview). Another preservice teacher described this process as something that is needed in their future as well:

> I think probably every time I start teaching a new grade I will think 'ugh, here we go again'. I will have to relearn these concepts to relearn how to teach them. I think it is probably something that will always be a little bit there. (Kailey, interview)

The preservice teachers described a consistent use of resources, mentors, and a reliance on colleagues when they struggle. They seemed to understand the importance of teaching mathematics and the struggles that are associated with being an effective mathematics teacher. Fortunately, these preservice teachers also indicated that although they are aware of the struggle, they were all up for the tasks. This *optimistic hesitance* to teach mathematics was a thread we will see in all three of these themes.

***Learning from their teacher education.*** All preservice teachers in this group mentioned

a change in their perspective and an overall improvement in their teaching practice over their time in their preservice teacher education program. These moments of improvement occurred both in their mathematics pedagogy course as well as during their placement in an elementary classroom with an associate teacher. One preservice teacher described their mathematics pedagogy course instructor as "amazing," how they "really transformed math" for them, and how the instruction made them "really comfortable in my placement this year to teach math more" (Beth, interview). Another preservice teacher discussed how they were not necessarily nervous to teach mathematics, but the mathematics pedagogy course helped them gain a better grasp on what and how they should teach. This preservice teacher offered insight into their experience with their methods course:

> Like I said, I have been comfortable with math, but getting the actual pedagogical skills and teaching tools and all of that…resources and having a great professor engage us that has definitely helped my confidence level in actually teaching it. (Jeremiah, interview)

There was also considerable discussion centered around the experiences these preservice teachers had during their placement in an elementary classroom. The benefits of these classroom experiences helped the preservice teachers grow as teachers and gain a better understanding of the expectations of mathematics instruction in an elementary classroom:

> I think I learned a lot by observing her teaching math and her own process of learning how to teach grade six math. I think after that experience I am more comfortable teaching math in the upper grades although I do recognize that I will have to do a lot of prep work before each lesson. (Kailey, interview)

Preservice teachers in this group also discussed not only seeing their associate teachers' success in teaching but also watching their associate teachers struggle with teaching mathematics or the preservice teachers struggling with their associate teachers. For example,

> It definitely helped me feel more comfortable because I think my teacher was fairly open about not always knowing all the answers and how it was OK. I think seeing her struggle and work through her uncertainties helped me a lot. (Marie, interview)

Another preservice teacher talked about their associate teacher having poor student reception to a specific mathematics lesson they taught and their associate teacher "losing sleep over it" (Samantha, interview). The preservice teacher found this experience impactful as they watched their associate teacher backtrack, re-plan their lesson, and then reteach it with success.

These experiences in the preservice teachers' mathematics pedagogy course mixed with their experiences during their placements were important to the preservice teachers' growth. The preservice teachers seemed to not only learn, but also gain a respect and better understanding of the amount of work that goes into teaching mathematics effectively. Again, we see an overarching thread of an *optimistic hesitance* to teach.

***A dislike for higher level mathematics.*** Interestingly, all the preservice teachers interviewed in this category mentioned that they either liked mathematics at a young age or they were at least proficient in the subject. All talked about being an average or above average mathematics student in early elementary school but experienced a change in perception early or late high school. Preservice teachers in this group described this transition to higher level mathematics as: "I remember in high school it just became so intense" (Kailey, interview), "I remember it being easy and loving it until maybe grade nine and then feeling more challenged

and thinking ‘oh, I don’t know if I am good at this. I don’t know if I can do it’” (Hannah, interview), and

> In elementary school I enjoyed math. I did well in math, and I didn’t find that it caused me too much stress or anything. I felt like my teachers never made it super scary or an intimidating thing. Then in high school, in grades nine and ten it was like that. (Kailey, interview)

It seems again that there is an almost *optimistic hesitance* towards mathematics. These preservice teachers seemed to understand they only have to teach mathematics at a grade six level or below, which they feel comfortable with, but they also know how challenging mathematics can get at the higher levels.

Overall, the preservice teachers in this “typical” category have gone through a constant push and pull regarding mathematics teaching anxiety, mathematics teacher efficacy, and mathematics anxiety. In terms of mathematics teaching anxiety, the preservice teachers were anxious to start teaching, but they know that they are life-long learners and will be able to push though with some work. In terms of mathematics teacher efficacy, the preservice teachers built their confidence in their mathematics methods course and practicum experiences, but they also started to see the amount of work that goes into being an effective teacher. Finally, for mathematics anxiety, the preservice teachers in this category felt confident in their mathematics ability for the K-6 grade content that they will be teaching, but they also had a dislike for higher level mathematics. This is an interesting tug of war going on with these constructs and it makes sense that these students are sitting in average for all these constructs.

This chapter has shown the results from the quantitative and qualitative analyses along with reliability and validity calculations for the quantitative measures. In the following chapter, I present some of the findings from this research using portraiture.

# Chapter Five – Portraits

## 5.1 Introduction

Fictionalized stories of conversations between a preservice teacher and their instructor of their mathematics methods course are given here to help understand the results provided by the qualitative analyses, quantitative analyses, and the mixing of the two methodologies. Using this strategy of writing portraiture, I can also draw from my experience as an instructor to help breathe life into these portraits. The portraits are presented this way because a conversation between an instructor and one of their students offers an experience which could be more relatable compared to the voice of an educational researcher doing an interview about mathematics anxiety, teaching anxiety, and teacher efficacy. Additionally, as this research is using multiple points of data (from both interviews and short answers responses) the portraits are a combination of multiple voices all with a common theme. These portraits are not from one specific participant, but rather from a variety of voices to draw inspiration. The names chosen for these portraits are intended to be gender neutral. The reason for this decision was not to erase anyone's gender or its importance to one's life but given that this study was not focused on gender issues, gender neutral names might better allow the reader to imprint their own vision of who each preservice teacher could be. Gender neutral names might help the reader to better interpret the results.

These portraits describe a one-on-one interview between an instructor of an elementary mathematics methods course and one of their students (a preservice elementary school teacher). The students of this course have previously had four weeks of in-class instruction, then a seven-week practicum experience, followed by another six weeks of in-class instruction. Their practicum experience involved the preservice teachers teaching in an elementary school classroom with varying responsibility alongside an associate teacher.

The preservice teachers in these portraits are getting ready for another six-week practicum experience where they will be asked to take on an even larger portion of responsibility in the classroom. This is their final week of instruction before they leave, and the instructor wants to check in with each student to see how they are feeling about their upcoming placement. For this class, the instructor has set up a variety of activity tables for the preservice teacher to rotate through. Periodically the instructor is pulling preservice teachers away from their activity to have a private conversation with them.

### 5.2 Jordan – High mathematics anxiety.

*"I was so nervous I would do poorly as my math skills are not very good. I practiced the night before and re-taught myself the material so that I could effectively help the students and enhance my own learning"*

– Short answer response from participant SA61 with high mathematics anxiety.

Even though the instructor was interviewing all their students today, they were especially interested in hearing from Jordan. Knowing that some, if not most, of their students have not engaged with mathematics in any formal manner in four or more years, the instructor set aside blocks of class time to go over fundamental mathematics content. These topics varied and included concepts such as place value, fractions, multiplication, and division. The purpose of these lessons was to "shake the cobwebs off" the mathematical side of the minds of the preservice teachers.

During these blocks of instruction focused on mathematical content, the instructor noticed that Jordan would often become less engaged and make comments about how they do not "get math" or that mathematics was "never their subject in school". Whenever the instructor came to help Jordan, Jordan rarely needed more than a nudge in the right direction. Often Jordan

only needed reassurance that what they were doing was correct. During one conversation specifically about mathematics anxiety in elementary students, Jordan made a comment about how they would classify themselves as mathematically anxious but then laughed it off with their peers.

Over the previous 10 weeks of instruction Jordan has been a very engaged student. All their work was done and submitted on time, but the quality of their work varied. The core concept of their work was sound, but their execution seemed to be lacking. The instructor believed Jordan's problem might be centered around their personal relationship with mathematics. The instructor was eager to see how Jordan was feeling about their upcoming placement, this is how their interview went.

The instructor had just finished and interview with a student and motioned for Jordan to come join them at their table. The table was still part of the class, but far enough away from any activity that a semi-private conversation could still be had. "How is everything going Jordan? How are you feeling about your upcoming placement?"

As Jordan was setting down their backpack and pulling out their chair to sit down, they answered, "a little nervous, but who isn't? I am looking forward to being back in a classroom and I hear my associate teacher is nice, so that's good".

"How are you feeling about teaching math?" The instructor expected Jordan to grimace or make comical face, but instead Jordan smiled and seemed eager.

"I am actually feeling pretty good about it" Jordan replied with a tone that could only be described as a sense of accomplishment. "I am definitely still nervous about everything, but found that by the end of my last placement I really started to get the hang of it. I mean, the first couple of classes were tough. I remember the first math lesson I taught was about multiplication.

I went up and told them how to do it, but half of them just looked at me with blank stares. During their work groups they all had different methods of solving the problem. They were mostly all getting the right answer, but I couldn't explain why or how they go to the answer. I felt like the students could see I didn't know what I was doing. That was definitely tough! It really shook me.

"After class that day my associate teacher sat down with me and we went through the lesson together. They gave me some helpful tips and I worked my butt off that night. I really wanted to nail the next lesson. I spent all night watching YouTube videos about the different concepts behind multiplying fractions. It actually cleared up a lot in my own head about it too".

The instructor smiled and asked, "how did the next class go?" They seemed genuinely interested in finding out.

"It went really well. The kids seemed to really get it. It was the first big challenge I had and the classes after that seemed to get easier and easier. It took a while, but I was able to get a sense for how fast or slow to go".

The instructor sat back, happy that their student had a positive teaching experience. They worried that if Jordan kept struggling then they might start to really get down on themselves. "How do you feel about your upcoming practicum then? Do you feel ready?"

"I think so", Jordan replied. "I know that I am going to be in a grade five class this time around, which means the math will be harder, but I have already started preparing". As Jordan was finishing their sentence, they reached into their backpack and grabbed their laptop. Jordan spun it around and showed the instructor the folder labelled "Grade 5 – Math". Jordan clicked the folder and dozens of files appeared. "I have been pulling together all of the resources we go over in class and even some my associate teacher gave me. Now, if I want to learn more about…", Jordan's sentence trailed off as they scanned the folder on their laptop that was placed

THEME – *High Mathematics Anxiety Pushing Teaching Practice Higher*

THEME – *Developing Strategies to Cope*

between them and the instructor. Jordan began speaking again as they clicked a file on their laptop "ordering fractions. If I wanted to learn more about how to teach ordering fractions, I have this lesson plan already made". The instructor looked over at Jordan's laptop and noticed the file Jordan opened was a full lesson plan for a lesson about ordering fractions.

"Wow, that is awesome. You don't have to reinvent the wheel when it comes to teaching. Especially in your first few years. I am glad you have been putting together these resources."

"I find them really helpful. It helps me break down the lesson into smaller more manageable chunks."

The instructor started to talk but hesitated briefly. They wanted to ask about how Jordan was dealing with their self-diagnosed mathematics anxiety and the affect it had on their teaching. The instructor had been curious about this ever sense Jordan made the comment about being mathematically anxious themselves. The instructor didn't want to put Jordan on the spot, but the conversation had been so positive so far that they felt it was OK to bring it up. "I remember one day in class you said that you 'weren't a math person' and you even once said you probably have math anxiety yourself. How are you doing with that? How do you find it is affecting your teaching?"

Jordan took a second to think, "I am still not one-hundred percent comfortable with math. There are still concepts I am really nervous about, but I know that if I work hard the night before and really prepare, I can push through. The main thing is that I am really conscious about modelling a good mindset for the students. I know that by modelling a positive attitude it will be picked up the same way as modelling a negative attitude. As long as I push through and show the students that even if I make a mistake, I can still learn from it, I think the students will be OK.

THEME – *Pushing Through the Anxiety*

Quote from Andrea

"It's funny, on my last practicum I had an experience with a student who was struggling. I felt that I could really make a connection with the student because I also struggled…" Jordan paused and chuckled "…am still struggling with the same thing. I was able to relate, and I think that helped build a better relationship with the student".

"It is good to let the students know that we make mistakes too and making a mistake is a sign of learning." The instructor checked the clock on the wall in their classroom. Even though the instructor wanted to keep the conversation going they knew their time was up. "Thank you for this chat Jordan, I am looking forward to hearing how things go on this placement!"

"Thanks!" Jordan replied and closed their laptop and started to stand up. The instructor looked over and waived the next student over to join them.

### 5.3 Alex – Low mathematics anxiety.

*"I just finished my first placement and was asked to teach an entire math unit (I said yes and stayed confident about my abilities)."*

– Short answer response from participant SA115 with low mathematics anxiety.

Alex was next on the instructor's list of students to interview. The instructor wasn't exactly sure what Alex's undergraduate degree was in, but the instructor was confident it must have been something in the STEM field. Alex was very comfortable with the mathematics content presented in class and regularly engaged in the pedagogical discussion as well. In class, Alex seemed to genuinely engage and reflect on the discussions and activities surrounding best teaching practices, even if Alex admitted to reverting to more traditional teaching styles in their actual teaching practice.

On a couple of occasions, the instructor had the opportunity to engage in deeper conversations with Alex regarding the benefits of pushing outside the teaching practices Alex

was accustomed to when they were learning mathematics as a student. The discussion always reverted to the fact that not all students learn in the same manner and what worked for Alex as a student may not be the best for all students. It was hard for a student like Alex, who seemingly enjoyed their mathematics experience thus far, to critically reflect on the experiences of others in the mathematics classroom. Like some, if not most, preservice teachers at this stage, the education system had worked for them. They are a product of what the education system expects from students. Unfortunately, one of the biggest lessons Alex still needs to understand is that their elementary classrooms will not be filled with twenty student who learn and think like Alex. Alex's classroom will instead be filled with a wide range of personalities, experiences, interests, and academic ability.

During these conversations Alex normally offered a few rebuttals, but eventually agreed. It wasn't always clear if Alex agreed because they had a revelation and change of thought or because they didn't want to argue with the instructor any further. Regardless, Alex always worked hard to do what they were asked and seemingly pushed themselves and stretched their pedagogical abilities to at least try new teaching techniques. Even with these efforts, the instructor still had an inclination that in the classroom Alex still had a high chance of reverting to traditional teaching practices. The instructor was interested in seeing how Alex had prepared for their upcoming placement.

The instructor waited for a moment when Alex was free and motioned for Alex to come and sit down. When Alex got closer the instructor asked, "Hey Alex, how are you doing?"

"I am doing well, how are you?" Alex sat down across the table from the instructor.

"I am good, thank you for asking, but I'm not the one who is starting their placement in a couple of days". The instructor cracked a small smile. "I am about to get a break from teaching, but you are just about to jump right in! How are you feeling?"

Alex quickly responded, "I am feeling good" then paused momentarily, "I think this time I am ready."

The instructor tilted their head inquisitively, "You weren't ready for your last placement?"

"I *thought* I was. I mean, I still did pretty well, but it wasn't exactly what I was expecting."

"How so?"

"Well, when chatting with other people in the class I felt pretty good. Most of the other people were *really* nervous about teaching math. I don't want this to come off the wrong way…" Alex lowered their voice a bit and leaned in closer "…but early on in this program I noticed that I am much more confident and better at math than a lot of my colleagues. I really wasn't worried much about the math portion of my placement."

THEME – *Relation to their Peers*

"What happened that changed your mind?"

Alex sat back and resumed talking openly. "Well, when I got into my last placement, I was teaching the geometry unit and I struggled at first because the math just made sense to me. It was difficult for me to put myself into the mindset of someone who is struggling with something. It was a while before I was able to understand where it was my students were getting stuck and how to tackle that part of it."

Quote from John

Now it was the instructor's time to lean into the conversation "what did you end up doing to overcome this?"

Alex took a deep breath and let out a small chuckle “I had to go back to the drawing board. I needed to take a step back and look at the expectations I set for my students. It was pretty concerning to take a look at my lesson block and realize that what I assumed would take the students one day to learn would probably take them three. It meant a lot of time reworking my lessons to fit the students. I mean, some students got what I was saying, and they understood the material, but I couldn’t just press on with more than half the class still confused. I needed to now find some way to entertain the students who understood the content, while also working to help those that were still learning.”

The instructor took a piece of scrap paper and wrote the numbers three, four, and five horizontally. The instructor then drew a normal curve above the three numbers centered above the four. The instructor was hoping this depiction would resonate with Alex’s assumed background in a STEM field.


“This is a way to think about a typical grade four classroom. It is safe to assume that the majority of the students are working in that grade four level of expectations, but you should always plan for a portion of your class to be still at one grade above and, hopefully, just one grade below.” As the instructor was explaining this, they were happy to see a look of recognition in Alex’s eyes.

Alex nodded and said “that makes sense. When I think back, I can visualize the groups of students that would fit into these categories.”

There was a short silence that was broken by the instructor "so, what do you have planned differently for this placement?"

"Well," Alex replied "I obviously have this new information and I have reworked my lesson plans to be a bit slower…" Alex paused and thought momentarily "…more *realistic* pace for my students. I have also been really working on utilizing low floor, high ceiling problems that allow for more differentiation in the classroom. This way, students who enjoy the challenge of mathematics can really sink their teeth into the problem, but for those that are struggling they can still access the material and work at their own level. I can help with all of the students at the level of math that they are engaged in."

"I think that is a great idea. Do you have any specific math problems in mind? These types of questions are truly beneficial for the classroom, but they can sometimes be hard to come up with."

Alex smiled as they gave their response "I think this is where I really shine. I think that this is the chance for me to bring my passion for math into the classroom. I truly think that the outlook we have on math can be contagious. I have a variety of questions that I have found in resources or came across in my past placement that I think are really fun and exciting. I think that if I show how excited and happy I am then the students will open up a bit more to it."

"Also, I am confident that I can find the math in almost anything. If a student seems to be disengaged with the problem, then I am sure I can take something they like and find the math in it. Sports? Video games? Baking? You name it. There is math everywhere, we just need to look for it."

THEME – *Bringing the Passion*

"There is a lot of power in bringing the passion for math when you teach", the instructor responded. "Let the students know that math can be fun and show them that math can be useful and there is a lot of it going on in the background of things we love, and we just don't notice it. Thank you for your time today Alex. I appreciate our chat." With this, the instructor smiled and stood up. Alex did the same and returned to their group.

### 5.4 Austen – High mathematics teacher efficacy.

*"I got the opportunity to teach math in a variety of different occasions on placement. I got to teach units on fractions, multiplication, and place value. I found lots of fun ways to make math interesting and engaging for students."*

– Short answer response from participant SA129 with high mathematics teacher efficacy.

It seems more often than not that when a preservice teacher looks forward to teaching mathematics, they usually decide to teach mathematics in the intermediate and senior divisions. It is a rare occasion that you get an elementary school preservice teacher who comes to the profession because they specifically enjoy teaching mathematics to elementary school students. In the case of Austen, it seems like this is one of those rare cases.

It didn't take long for the instructor to take notice of Austen, as Austen was routinely involved in classroom discussion, always on task, and frequently went above and beyond on their assignments. The instructor truly enjoyed teaching Austen. Austen was the type of student that brought their own individual strategies of how to teach mathematics into the class but instead of Austen's ideas clashing with those put forward by the instructor, Austen instead used their own ideas and concepts in conjunction with those put forward by the instructor to improve Austen's teaching even more. Austen seems to value the ideas brought up in class instead of dismissing them because of their own prior held beliefs.

The instructor looked forward to their chat with Austen. The instructor waited for a moment when Austen was available and motioned for Austen to come join. “Hello Austen, thank you for coming over”, the instructor said while motioning for Austen to take a seat.

“Hello,” Austen replied with a smile on their face. Contrary to some other students, Austen looked like they were truly looking forward to sitting and talking about their upcoming placement.

“How are you doing? How do you feel about your upcoming placement?”

Austen smiled and replied, “I feel great. I think this time I am truly ready for it. Hit the ground running. I am looking forward to it”.

Surprised slightly, the instructor replied, “you weren’t ready last time?”

Austen thought momentarily and replied, “well, it’s not that I wasn’t *ready* last time. There were just a few stumbles at the beginning, but I feel like I really got the hang of it at the end”.

“What sort of stumbles?”

“It’s hard to truly get an understanding of what a classroom is really like until you are there and in it. In class we talk about this *mysterious classroom*, but I think everybody has a different interpretation of what this classroom looks like. The classroom I was in for my last placement definitely did not match what I was thinking.”

“What was so different?”, the instructor asked.

“The students…”, Austen paused as they were trying to find the right words, “…they weren’t what I anticipated. Well, that’s not right. They were exactly what I anticipated socially. Busy and hard to control at times, but they weren’t where I expected them to be academically. For instance, I was using geoboards to teach grade 2 students about geometric shapes and the

Quote from SA6

lesson did not go well. The students did not know how to use the geoboards and were not ready to creates sides and vertices on their own."

The instructor, with a sympathetic tone in their voice almost to indicate that they had had a similar experience asked, "that's not great at all. What happened in the rest of that class?"

With a smile on their face, Austen said "I'll be honest, it wasn't great. The cool thing though is that later that day I went back to the drawing board, did the same lesson the next day starting at the very beginning and it went very well! It ended up being a really good learning experience. I had to almost recalibrate my expectations and after that the teaching went a lot smoother."

THEME – *Overcoming Early Obstacles*

The instructor was impressed and a little proud of their student. The instructor tried not to show too much emotion, but they couldn't hold back a smile at the very least, "going back the next day and doing the same lesson again is courageous. What motivated you to go back and re-plan the same lesson? That must have been a lot of work in a short amount of time."

Austen smiled back and replied, "it wasn't too bad. Going back and re-planning a geometry unit was kind of fun actually. I mean, I enjoy teaching math and I enjoy doing math too. For me, math was always a strong point especially in elementary school where I didn't have to work hard at it at all."

Quote from Mike

"That is good to hear. Do you think this experience will stick with you and help you with your upcoming placement?"

"Definitely. I feel like, at least at the beginning, I should take things slow and then speed up if the class responds well. I feel like having that speedbump early on really helped me wrap my head around things. I mean, the first class I ran using the geoboards was pretty awful and I made it out of that alive right? At the end of the day it is just math. Worst comes to worst I can

THEME – *Enjoyment of Mathematics*

just have some fun with it and make it through that lesson, go back, and retackle it again tomorrow."

The instructor smiled, let out a small chuckle and replied, "exactly. I am glad things went well for you and that you are looking forward to your next placement. Thanks for chatting today Austen. I appreciate it."

"No problem." Austen smiled and got up from the table to rejoin their group.

### 5.5 Charlie – Low mathematics teacher efficacy.

*"I still get a little bit of math anxiety when I am teaching, but I think it will be less so when I am in the teaching environment."*

– Interview response from Rachael

Throughout the year, the instructor was always intrigued by Charlie's input in the classroom. Charlie always had a different perspective on mathematics and teaching mathematics that seemed to be contradictory to what the instructor expected. This isn't to say that Charlie had an improper view of the concepts and ideas, instead it would be best to describe Charlie as looking at the problem from a different angle. For instance, during the lesson focused on data management the instructor was describing an activity where students collect data from their class or school and then discuss the best ways to display this information in a graph. Most of the preservice teachers had questions centered around the immediate task of the lesson. For example, common questions were "what *is* the best graph to use?", "how long should we give the students to collect data?", and "how would you best assess student's work here?". Instead Charlie would ask questions with a larger scope such as "what do you do if a group of students is done faster than any other group?", "how do you make this question accessible to students who struggle with

this concept?", and "how do I take this lesson and link it to another lesson in data management going forward?".

Charlie's questions were always relevant and important to address but they always caused pause in the instructor. The answers were rarely simple and often had a complex answer that unfortunately didn't always seem to be to Charlie's satisfaction. These types of questions were always welcomed by the instructor, but the instructor also began to pay extra attention and prepare themselves when Charlie had a comment or put forward a question or idea. It seemed like Charlie was striving to answer the holistic question of "how do I teach mathematics?" as opposed to smaller bit sized problems of "what are different forms of mathematics assessment?" or "what are common problems students run into when dealing with place value manipulation". The instructor wanted to investigate why Charlie had such a different viewpoint. Was it a specific instance in their placement? Possibly something that arose in them during their time as a mathematics student. The instructor was not sure, but they were interested in finding out more.

This time the instructor had to stand up and find their next student to chat with as everyone in the class seemed to be busy working away on one thing or another. Today was a good day as *most* of the work being done was seemingly mathematics focused although students on their laptops still quickly clicked away windows when the instructor walked by. While walking by groups the instructor managed to lock eyes with Charlie and the instructor took that opportunity to motion for them to come over for a chat. "How is everything going Charlie? You mind if we chat next?"

"No problem" Charlie replied. Given the way Charlie was situated amongst their group they had to motion to their peers to slide over for them to get out and come join the instructor. It

took Charlie a few minutes to jostle their way over their peers and by the time Charlie was free the instructor was already at the table that was set up for their chat together.

"Thanks for coming over and chatting Charlie. I hope all is going well. I wanted to see how you are feeling about your upcoming placement".

"I am feeling…", Charlie paused and thought about their next choice of words, "…OK about my placement". Charlie cracked a smirk while they said this in an indication that they weren't overly worried about what was coming up but rather not looking forward to their experience. This tone wasn't meant to hide anything from the instructor and the instructor quickly picked up on this.

"Why just OK? A little hesitation there, I noticed. What's up?"

"Well, my last placement was in a split class. The majority of the students were in grade two but about six or so were in grade three. When I was teaching math, my associate teacher had me take the smaller group of grade threes and work with them. It was much easier working with a smaller group of six. For my next placement I am working in a grade five class. I am worried that with the larger teaching load coming up and a full class of almost thirty students that it is going to be really challenging managing all of those students."

"What do you mean by challenging? Do you mean general classroom management?"

Charlie shook their head, "no…well yes, classroom management will be a challenge but that isn't really specific to math. A group of grade five students will be a challenge no matter what lesson I am teaching. I was more thinking about being able to make math interesting for a room of thirty students."

The instructor was a little surprised by this response. During the time the instructor spent with Charlie they never got the sense that they were necessarily worried about teaching math.

They always seemed to be on top of everything. Charlie seemed to have a solid grasp on the content and was always conscious of the pedagogy as well. “What are you worried about specifically? The higher-grade level may be a bit more of a challenge to teach but—”.

Charlie jumped in, “no, it’s not the material. I don’t mind the material at all. I actually find it a bit more interesting to teach. You can do a lot more with the higher grades. The problem I am worried about is that there will be so many students with so many different learning styles! The major thing I took away from this class is that not all students learn the way that I did.”

“How did you learn math when you were a student?”

“I don’t 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 repetition 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 that way I learned. So, trying to teach kids to learn in a way that I never learned is mindboggling.”

The instructor was surprised but also at the same time not surprised. They didn’t expect this sort of internal struggle to be going on with Charlie, but the more the instructor thought about it the more it made sense. This disassociation between how they were taught and how they are being asked to teach seemed to fit the concerns Charlie had been trying to get at all year. The instructor took a second to process everything. “Has this been a challenge all year for you?”

“Somewhat yes. I feel that as much as I am learning these other ways of doing something, I feel like there is always that chance that I will stick to what I knew best and how I learned best.”

THEME – *Comfortability with Mathematics*

Quote from Mel

THEME – *Taught one way, asked to teach another*

Quote from Riley

The instructor sat back and took a minute to think. “That can be a problem and it can happen to a lot of teachers. It is good to see that you are conscious of these pitfalls of teaching. That is the first step to improving the way you teach. The next step is doing the prep work to prevent this from happening again.”

Quote from Ryan

Charlie smiled “Yeah I agree with that. I think that because I worry about it that I will put more effort into trying not to just revert back to the way that I learned it and how I know it.”

“That is good to hear. Just remember that being a better and better teacher is something that you will be working towards for your entire career. There will be good and bad days, but every day you will get a little better. I think you will do well on your placement”

“Thanks. I hope so.” And with that the instructor stood up as did Charlie. The instructor had a good feeling that Charlie would do well on their placement but knew there were still a few road bumps for Charlie to overcome before they truly felt comfortable teaching mathematics.

### 5.6 Logan – High mathematics teaching anxiety.

*“I need to be well prepared for a lesson for it to run smoothly and since I was unable to teach the lesson I had planned for; I felt sick to my stomach and was completely lost. I didn’t know what to do.”*

– Short answer response participant SA157 with high mathematics teaching anxiety.

Logan was, for all intents and purposes, a pretty typical student in the eyes of the instructor. If anything stuck out about Logan it was Logan’s over preparedness that caught the instructor’s attention. On several occasions the instructor took the time to chat with Logan about an upcoming presentation or assignment and almost every time the instructor found themselves explaining to Logan that Logan was doing *more* work than the instructor originally intended. The instructor found that Logan was taking an assignment that was expected to take an hour to

complete and spending multiple hours on what were relatively minor details. The work done was always well put together. The instructor didn't believe that Logan struggled with the content, instead the instructor believed Logan overthought most of the ideas and concepts.

The instructor also noticed on multiple occasions that Logan was what could be called a "mathematics resource hoarder". Logan gathered any and all mathematical resources that came their way. These included both physical and digital copies of resources that focused on both mathematical pedagogy as well as content. The instructor never had to urge a student to *not* save a resource for later use, but Logan was getting close. At a certain point quantity starts to outweigh quality and this can become a problem. Regardless, the quality of Logan's work never diminished so the instructor never had any reason to worry about Logan's classroom work, but the instructor was curious about how Logan was doing in the elementary school classroom.

The instructor made their way over to Logan who was working with their group. When a break in conversation came about the instructor leaned in and said, "hey Logan, sorry to interrupt. Do you mind if we have a quick chat about your placement coming up?"

"Sure", Logan replied and gave a nervous look to their friends as they left the group to come to the table and chat with the instructor.

"How is everything going Logan?", the instructor asked. "Do you feel ready for your upcoming placement?"

Logan took a long breath in, held it and then exhaled, "I think so."

"Think so?", the instructor said with a small chuckle. "What's going on?"

Logan thought for a second, started to speak then stopped. Finally, they said with a laugh that seemed to come half from a place of playfulness and half from embarrassment, "teaching math can be so hard sometimes."

The instructor sensed the little bit of nervous tension in Logan's voice and tried to break this tension with a bit of humor, "you should try teaching how to *teach* mathematics. It doesn't get easier there." Logan and the instructor shared a small laugh, enough to break the tension. "What specifically are you finding so challenging about teaching? Is it the content? I remember you saying you were in a grade six classroom for your last placement. There are some units at that grade level that can be challenging."

"No, it's not that. I don't mind the actual math part of it really. I always really liked math, especially in elementary school and high school. I took it all the way until grade eleven and I enjoyed it. I was always a step behind where I needed to be, but I was always enjoying it. I always did catch up. It just took me a little extra time."

"So, you always really liked the math class as a student, that is good. What about—". Logan quickly interrupted the instructor as they were talking.

"Well, I wouldn't say I fully liked the math *classroom*. I didn't mind doing the subject math, but when you mentioned the math *classroom,* I have some different feelings come up."

"Oh? Like what?"

"Specifically? Well, I remember one teaching who outright said I shouldn't do math anymore. That wasn't great. That's kind of a dramatic instance, but overall I think I just had too many teachers who gave off the 'I don't like math and we are doing this because we have to' sort of attitude which was always a damper on my efforts as a student."

"Woah". The instructor was at a loss of words. They didn't expect to hear such a strong response. It is common for students to have disliked their mathematics classroom, but rarely do students ever have an instance of a teacher outright telling them to stop doing math. "Do you think this is what is causing your hesitation to teach math?"

Quote from Shelly

Quote from Mel

THEME – *Good student, poor student experience*

Quote from Shelly

Logan took a second to reflect. It appeared that Logan had never really taken the time to think about this. “It could be. I mean, I really don’t want to be that kind of teacher to my students. It really made math a bigger challenge than it needed to be. Thankfully, I still made it through, but what about the students that already struggle with math? Or the students that already don’t like it? I worry that I might be one of the math teachers they have bad memories about later in their life.”

The instructor put on a comforting smile and replied, “you know, being worried about this is a good thing…” the instructor paused then looked at Logan, “…to an extent. Don’t let this work itself up too much in your mind. Being aware of this means you care about your teaching. That is good. We need to change our perspective from worrying about what could go wrong to moving towards better practices that push us in the right direction. What do you have planned to help you with this?”

Quote from SA132

Quote from Mel

“In the placement I have had so far I taught math for one week. I was very stressed when I first started planning lessons. I started referring to some of my resources to help with this and it went much better after that. I find that a lot of my tension in teaching is when I get focused on the overall things, instead I found that if I focused on the lesson and leveraged resources to go back to the effective strategies for teaching math it helped a lot.

THEME – *Resources*

“I think that is a great strategy! We don’t have to reinvent the wheel to teach math, especially when we are just starting out. I feel that there is an inhibition to *teaching from the textbook*. This only holds true when you have a terrible textbook, which was the case at some point in the past. Fortunately, now we have resources that were made by teachers for teachers. There is nothing wrong with taking inspiration from the abundance of resources we have”.

Logan smiled, “Yeah, I find that there are some amazing resources online and in our library. Sometimes I wish I could have given these to my old teachers. I would have loved to do some of these activities as a student”.

“That is good, but just remember to still have a critical eye when you are going through resources. Not all of them are the best, and with the abundance of information out there it is easy to get lessons that look nice but won’t work in most classrooms.”

Logan smiled, “I agree. I have seen some that are…not the best”.

After a moment of silence, the instructor spoke up, “so do you think that sounds like a plan going forward? I know it is hard but try not to worry about the negative things. Let’s work towards making moves in the positive direction. Use those resources you have, and I am sure you will do amazing!”

“Thanks. I really hope so!”. What that, Logan and the instructor said goodbye, stood up, and the instructor looked to pick their next student.

### 5.7 Riley – Low mathematics teaching anxiety.

*“I taught math to little kids. They liked it because I wasn’t just using a textbook. Being creative in math is easy if you try”*

– Short answer response from participant SA8 with low mathematics teaching anxiety.

The instructor was nearing the end of their students. The instructor looked around to see which students they hadn’t had a time to chat with. Riley was one of the only students left. The instructor purposefully left Riley as one of the last students as this was a student that the instructor was worried the least about. Out of all the instructor’s students, the instructor was willing to miss the conversations with Riley if the discussions with the other students ran long

and there was no time to chat. Thankfully, the instructor had time to sit down and chat with Riley.

Throughout the year Riley had exhibited confidence and proficiency in both the pedagogical content knowledge and the content knowledge surrounding mathematics. Riley was an easy student to teach and was always willing to put in extra effort, volunteer their ideas, and push themselves outside of their comfort zone in class activities and demonstrations. On multiple occasions in class Riley had volunteered to take the place of an elementary classroom student to demonstrate a teaching technique such as a number talk or math game. Often, silence is the response when the instructor asks for a volunteer. The instructor was always thankful for Riley and students like Riley because they were always there to volunteer and break the silence.

With this being near the end of the class it was not hard for the instructor to find a time to interject into a group of students. Most groups were either finishing up their task or were at the end of their attention spans. The instructor took this opportunity to step in and pull Riley away for a quick chat. “Riley, do you mind if we chat quickly?”

“Yes of course!”, Riley replied. Riley seemed eager to sit down and chat about their teaching. Both the instructor and Riley made their way over to the table and made themselves comfortable.

The instructor was the first to talk, “How have things been going? How do you feel about your upcoming placement?”

“I am actually really looking forward to it. No offence to you or anything, but I am glad to be back in the classroom. I miss the students”.

The instructor smiled, “no offence taken at all. The classroom is a busy but exciting place to be. I am glad to hear you are so eager to get back. What grade are you teaching?”

"I will be in a grade 5/6 split class in a school back home."

"5/6 split class? That is exciting. I remember you saying that your last placement was in a grade one class and you were looking forward to teaching some higher grades next. I am glad to hear you got this placement!"

"Yes, I am really looking forward to it. I will have to change some of my teaching techniques for the older grades though, obviously."

"What sort of things?"

"Well, I really developed a bond with the grade one students from my last placement, especially when it came to teaching math. They knew how much I loved math. I don't care what it is, when I meet a stranger and they tell me about a passion that I know nothing about sometimes their enthusiasm is just contagious and that is me with math. The kids thought it was really funny and they loved it. I think that just because I love math so much that I am better at teaching it. I am obviously confident, and I am happy. The kids were engaged, and they thought it was very fun. We had marvelous math Mondays; it was just a thing. I had a crown and it had numbers on it. I was math royalty! They really liked it. They thought it was cheesy at first, but then they really got into it."

THEME – *Mathematical Content Knowledge*

Quote from Riley

The instructor was grinning from ear to ear. Normally, being *math royalty* was something students would never do, or if they did, they wouldn't be nearly as confident or proud of it. This sort of enthusiasm and enjoyment for mathematics is what separated Riley from the rest of the students. Riley seemed to not only have an enjoyment for mathematics, but they were also not ashamed to express their joy. To Riley, math almost seemed to be a part of their identity—a part of their identity that they were proud of. "That is hilarious. The students must have truly loved that".

Riley ginned, “yes they did, but I don’t think it will go over as well with grade five and six students, but I enjoy math so much. I am sure I will be able to pass that along to my students.”

“You are right, the *math royalty* might not go over as well with the older students, but do you think there is something that you can take away from your first practicum?”

Riley thought for a moment and replied, “yes I do. Before the math royalty thing there were a few hiccups. Teaching in my first placement has helped me with understanding people’s different ways of thinking and problem solving. I always understood math myself pretty easily, but not everybody thinks the same way. I need to slow myself down and make sure that people are following when I am teaching math as opposed to nodding through it and getting lost. That is my big takeaway from my last practicum.”

Quote from John

THEME – *Overcoming obstacles*

“That can be a tough lesson to learn and one that often comes up in the classroom for beginning teachers.”

Riley nodded, “Yes, I think it is something that I have battled with; the fact that I have always been proficient with math. I have to take a set back and look at it and realize that not everyone is proficient in math and I need to be ready for the fact that not all of these kids are going to get it with the one explanation I have. I have to come up with three or four strategies to solve this. I think it is a more effective way of teaching. When I was a student you had one way to do it and if you didn’t do it that way then it was wrong. Now, with multiplication, I have four or five strategies that I will teach the kids and I don’t care which way they do it as long as it solves the problem.”

Quote from Mike

THEME – *Mathematical Content Knowledge*

The instructor nodded in agreement. “That is a great strategy to carry forward with you. Not only for this placement, but for teaching going forward.”

"I hope so. I am eager to start my next placement off on the right foot. I feel like I know so much more this time around. When I first started in this course, I became overwhelmed with all of the teaching strategies we were told about. It was scary at first to be honest. But once I was able to explore a bunch of different options, I found out that most of what I am doing aligns with current research. I don't have to change anything. The way I am teaching math and the way that I approach math and the way that I fell about math is already successful. The kids are benefiting."

Quote from Riley

"I am glad you feel so confident going into this placement. You have definitely put in the work. I am excited to hear about your experience when you come back! Thanks for taking the time to chat Riley".

"Thank you too", Riley replied. The instructor and Riley then both stood up with Riley returning to their group and with the instructor checking the clock to see if they had time for one more interview.

### 5.8 Sam – Typical student

*"During my placement my associate teacher observed me teaching my math lessons. I felt a bit anxious about this as math is not a subject that I regard as one of my strengths, but I am eager to learn how to teach this subject and to help the students learn"*

– Short answer response participant SA32 with average levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy.

The instructor looked around the room for any remaining students to chat with before the instructor dismissed class. The instructor inhaled in preparation to make the announcement when their eye caught sight of Sam. The instructor realized they completely forgot about Sam. This wasn't necessarily hard to do as Sam was an average student in almost every way and tended to just blend in. Sam volunteered answers every once and a while, always handed in their work

completed, on time, and was of adequate quality. Thinking back about Sam, the instructor realized that more often than not Sam would turn to their colleagues for support rather than make a scene or "disturb" the instructor. Sam was more of a self-sufficient student than anything. Going through the class not making waves neither good nor bad.

This was an opportune moment for the instructor to sit down and have a chat one-on-one with Sam. A chance, or at least a reason, to devote attention to Sam specifically. "Sam", the instructor walked slowly to where Sam and their group were working. "I was hoping we could squeeze in a quick chat before class is over."

"Of course", Sam replied. Sam then stood up, pushed their chair in, and followed the instructor to the desk at the other side of the classroom.

"How are you doing today Sam? How do you feel about your upcoming placement?"

"I feel OK. I learned a lot from my last placement so I think this one will be better, but I know I still have a lot more to learn."

"What do you mean?"

"I still feel a little nervous. Just because looking back as a student I forget what we used to learn. Otherwise, I felt pretty OK and I feel like math is structured enough to know what to teach. I feel comfortable with the curriculum to follow that and there are so many resources now a days, especially with math. I realize that I am always going to be a student and I am never going to stop learning."

Quote from Becky

THEME – *Always Growing and Learning*

"That is a good mentality to have. When we stop learning as teachers we stop growing as educators. It is important to keep working towards being better. Do you think you need to improve your math teaching or your math in general?"

Sam took a moment to think and then responded, "both I think. As a student I was good at math, but it never really struck me as something I wanted to do for my career. I remember math being easy until a certain point, probably grade 9. Then it just got a little bit too much to be enjoyable anymore. Thankfully, I know I will only have to teach up until grade 6 at the most. I feel comfortable enough there."

"What about teaching math? How do you feel about that?"

"That is something that I think I have improved the most on. I mean, before starting here in the teacher education program I had no real idea what it was like to teaching math. Both my time here and in my placements so far have taught me so much about teaching math."

The instructor couldn't help but feel a sense of pride hearing this. This sort of thing is exactly what the instructor is looking to hear in these conversations. "What particular things helped you out?"

"In this class it was learning all of the great teaching strategies. I have included these strategies into every lesson I taught during my last practicum. Specifically, I remember leading a math manipulatives workshop in class. Here, I presented and lead my colleagues through a coloured tiles workshop on how to effectively use this manipulative across all primary and junior grades within all strands of the curriculum. When reflecting on that workshop I am reminded of my confidence presenting and my ability to differentiate my instruction as required."

Quote from Jason

Quote from Hailey

THEME – *Dislike for Higher Level Mathematics*

Quote from SA170

Quote from SA134

THEME – *Learning from their Teacher Education*

Again, a smile crossed the instructor's face. "I am glad you were able to take so much away from that lesson. How about your placements? What have you taken away from them about teaching math?"

Surprisingly, Sam took almost no time to reply to this question. They knew exactly what experience they wanted to share, "I think my teacher was fairly open about not always knowing all the answers and that is okay. I think seeing her struggle and work through her uncertainties helped me a lot. The school I was placed at also had an instructional coach and her specialty was math. So, my teacher and her coach worked a lot together. It was a cool experience working with them."

Quote from Kelly

"That must have been a great experience! It is good to see that even veteran teachers are struggling and are still working towards becoming a better teacher and that is okay."

"Yeah, that experience really opened my eyes to that side of teaching math. It helped calm my nerves down a bit knowing that I will never know everything and that is okay. I just need to work on always learning a bit more every day."

"I think we can all push to learn something new about teaching mathematics, maybe not daily, but at least weekly." With that being said there was a pause until the instructor spoke up again, "so overall it sounds like you are feeling good about your upcoming practicum?"

"I think so. I know there will be both good and bad days. At least during those bad days, I will be learning something, right?"

The instructor and Sam both let out a chuckle and they both stood up. "Thank you for the chat today, Sam. I appreciate it."

"Thank you too. See you after the break!"

## 5.9 Conclusion

The portraits above are examples of how varying levels mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy were experienced in preservice elementary school teachers in Ontario. These portraits, although fictional, provide examples of preservice elementary school teachers with varying levels of these constructs. Through these portraits a voice is given to those preservice teachers who may otherwise be overlooked or miscategorized as "a struggling student who just needs to work harder." These portraits serve to help understand preservice elementary school teachers and their relationship with teaching mathematics.

In the following chapter the results from both the qualitative and quantitative data will be presented with the literature to provide a discussion surrounding this dissertation and what the results have to contribute to mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy in elementary school preservice teachers.

# Chapter Six – Discussion

## 6.1 Introduction

In order to gain a better understanding of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy in preservice elementary school teachers across Ontario, this discussion will pull from the relevant literature as well as the results from the qualitative and quantitative analyses. Here the quantitative and qualitative results are mixed and used together stand as the framework for this discussion. With the large number of responses, the quantitative results provide an opportunity to discuss the breadth of results while the qualitative results provide the depth that is missing from an examination of the quantitative results alone. Together these data findings are used to answer the research question and sub questions:

1. What role does mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy have on preservice elementary school teachers in Ontario?
    a. What is the relationship between mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy?
    b. How are varying levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy experienced in elementary school preservice teachers in Ontario?

To answer the first sub-question, the quantitative and qualitative results from the questionnaire were used as well as qualitative data from the interviews. For the second sub-question, the quantitative and qualitative findings are mixed and used together to create portraits displaying the impact varying levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy can have in preservice elementary school teachers.

## 6.2 What is the Relationship Between Mathematics Anxiety, Mathematics Teaching Anxiety, and Mathematics Teacher Efficacy?

This research is focused on how the three constructs—mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy—interact with each other. The aim is not to determine how all three constructs interact as a group, but rather to see how each of the three constructs interact with one another. Specifically, this research looked to investigate the relationship between mathematics teaching anxiety and mathematics anxiety, between mathematics teaching anxiety and mathematics teacher efficacy, and between mathematics anxiety and mathematics teacher efficacy. These relationships are represented by the arrows in Figure 10 and each relationship will be discussed below.

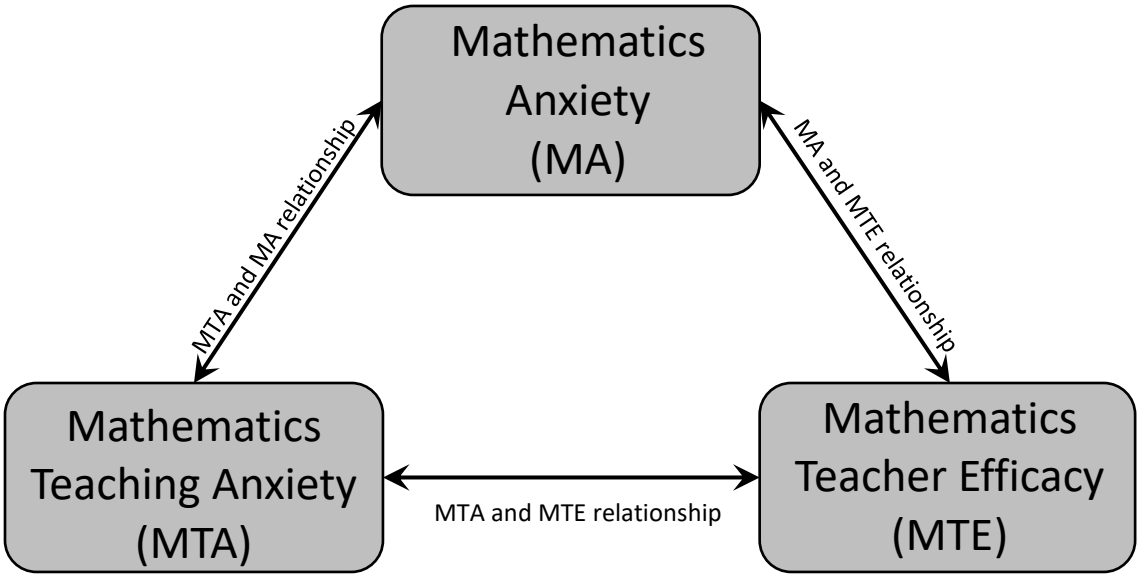


*Figure 10*. Relationship between constructs.

**6.2.1 Mathematics teaching anxiety and mathematics anxiety.** Research on mathematics teaching anxiety is relatively scarce compared to the other two constructs. Of the

research that has been done, a positive correlation has been shown between mathematics teaching anxiety and mathematics anxiety (Adeyemi, 2015; Haciomeroglu, 2014; Peker & Ertekin, 2011; Unlu, Ertekin, & Dilmac, 2017; Hadley & Dorward, 2011). Interestingly, some research brings to light a disassociation between these two constructs (Brown, Westenskow, & Moyer-Packenham, 2011).

Turning attention to the findings of the present research study we see that overall mathematics teaching anxiety, as measured by the total of the Teaching Anxiety Scale (TCHAS), was positively correlated to overall mathematics anxiety, as measured by the total of the Revised Mathematics Anxiety Rating Scale (RMARS). We also have positive correlations between mathematics teaching anxiety and the subconstructs of the RMARS (mathematics test anxiety, numerical task anxiety, and mathematics course anxiety). This relationship between mathematics anxiety and mathematics teaching anxiety is to be expected as it reflects previous research.

Interviews and short answer responses from the preservice elementary school teachers in this research provide insight into the correlation between mathematics teaching anxiety and mathematics anxiety. For preservice elementary school teachers with low levels of mathematics anxiety there are reduced levels of mathematics teaching anxiety as the preservice teachers believe they can *bring their passion* of mathematics to their teaching. Preservice teachers with low levels of mathematics anxiety believed that their comfortability with mathematics will overshadow or be able to overcome any stumbles they may have while teaching mathematics. These preservice teachers talked about “enthusiasm being contagious” and “the kids knowing how much I love math.” Low levels of mathematics anxiety in these preservice teachers seemed to afford them a comfortability with the mathematics content that reduced the anxiety in their teaching ability.

Preservice teachers with high levels of mathematics anxiety do not have a passion for mathematics to fall back on. Instead, these preservice teachers talked about falling back on resources and having to be proactive in developing strategies to cope with their mathematics teaching anxiety. Interestingly, when talking to the preservice elementary school teachers with high mathematics teaching anxiety and/or high mathematics anxiety, most still expressed a positive attitude towards teaching mathematics in the future. These preservice teachers were aware of their attitudes towards mathematics and teaching mathematics. This apprehension was not necessarily debilitating, but rather these preservice teachers knew that extra work needed to be done. These preservice teachers understood that, compared to their peers, they would need to plan more beforehand, use additional resources, and spend extra time debriefing and reflecting after a lesson.

6.**2.2 Mathematics teaching anxiety and mathematics teacher efficacy.** Of the research that looks at mathematics teaching anxiety in combination with mathematics teacher efficacy, findings indicate that mathematics teaching anxiety and mathematics teacher efficacy are negatively correlated (Peker, 2016) and that the most important variable affecting mathematics teaching anxiety is mathematics teacher efficacy (Unlu, Ertekin, & Dilmac, 2017).

The results from this research show similar trends in the data. Specifically, we see mathematics teaching anxiety, as measured by the TCHAS, has a moderately negative correlation to overall mathematics teaching anxiety, as measured by the TSES. When looking at the subconstructs of mathematics teacher efficacy we see consistent moderate negative correlations between mathematics teaching anxiety and efficacy for instructional strategies, efficacy for classroom management, and efficacy for student engagement.

The data provided by this research supports current research behind the relationship between mathematics teaching anxiety and mathematics teacher efficacy. That is, that high levels of mathematics teaching anxiety in a preservice elementary school teacher correlates to low levels of mathematics teacher efficacy and vice versa. This correlation is to be expected as a preservice elementary school teacher with low levels of mathematics teacher efficacy would have little belief in their ability to control, manage, and impact students in their classroom. This lack of confidence in their ability could cause an increase in their fear of teaching mathematics as they do not believe that they have the ability to overcome something going wrong in their mathematics classroom, leading to an increase in their mathematics teaching anxiety. Using the qualitative data provided by the interviews and short answer responses, more information can be brought to the details of this correlation.

Amongst the subconstructs of mathematics teacher efficacy, the efficacy for instructional strategies was shown to have the highest negative correlation with mathematics teacher efficacy. In the interviews, preservice elementary school teachers with low levels of mathematics teacher efficacy indicated that they were *small scale confident, but large scale worried* about their teaching. This seemed to indicate that the day-to-day classroom management and student engagement were less of a worry for these preservice teachers, but the struggle with being *taught one way, but asked to teach another way* paired with the demand to reach all of their future students through differentiated instruction could be the cause of their mathematics teaching anxiety.

The preservice elementary school teachers with low levels of mathematics teaching anxiety shared experiences of *overcoming early teaching obstacles* during their placements. This could prove to be a catalyst for beginning a cycle of overcoming an obstacle in their mathematics

classroom therefore increasing mathematics teacher efficacy, which causes a reduction in mathematics teaching anxiety, therefore causing a stronger belief and ability to solve future problems in the mathematics classroom, which in turn increases mathematics teacher efficacy and so on. The connections made between the qualitative and quantitative data of the current study is in accordance with the scarce amount of literature surrounding mathematics teaching anxiety and mathematics teacher efficacy.

**6.2.3 Mathematics anxiety and mathematics teacher efficacy.** Unlike the previous three sections, the interactions between mathematics anxiety and mathematics teacher efficacy are relatively well researched. Current literature supports a negative correlation between mathematics anxiety and mathematics teacher efficacy (Gresham, 2008; Swars, Daane, & Giesen, 2006; Unlu, Ertekin, Dimac, 2017). Interestingly, the data from this research does not fully align with these conclusions.

Looking at the correlational analysis between overall mathematics anxiety, as measured by the RMARS, and overall mathematics teacher efficacy, as measured by the TSES, there is no significant correlation between the two constructs. Additionally, very few of the subconstructs of the RMARS share any correlation with the subconstructs of the TSES. Of the correlations that are significant all are below levels that would indicate a weak correlation. This lack of correlation between these two constructs is interesting in its contrariety to the current literature. The data from the interviews helps provide insight into what might have been going on with these preservice elementary school teachers.

In the qualitative data, it was found that many preservice teachers with high mathematics anxiety were aware of their anxiety and believed that they could *push through their anxiety* and at the very least model a positive mindset towards mathematics. These preservice teachers were

able to separate their negative personal relationship with mathematics content from their teaching relationship with mathematics and these preservice teachers believes that as long as they modelled a positive attitude towards mathematics then their students would pick up on this and have positive attitudes themselves—leading to positive outcomes. In these cases, preservice teachers with high mathematics anxiety still believed they could impact their students positively and therefore maintain higher levels of mathematics teacher efficacy.

Not surprisingly, preservice teachers with low mathematics anxiety expressed an aptitude for mathematics but some of these preservice teachers claimed that their achievement as a mathematics student was a hindrance to their ability to teach. These preservice teachers claimed that, as students, they never had to think about multiple ways to approach a problem and they had very little experience with struggling with mathematics content. This lack of experience prevented them from being able to fully support their struggling students. In this case, low levels of mathematics anxiety were associated with lower levels of mathematics teacher efficacy—contrary to our current understanding.

Another interesting discovery was that of the preservice teachers with low mathematics teacher efficacy, many still had moderate or low mathematics anxiety. When asked about their concerns about teaching mathematics these preservice teachers talked about how they were asked to teach mathematics in a way that, as students themselves, they were not taught. Specifically, these preservice teachers talked about a very "drill and kill" mentality of mathematics instruction filled with worksheets and rote memorization. Although this type of mathematics instruction is frowned upon now, these preservice teachers found success in this environment. These preservice teachers were *taught one way but asked to teach another* and this caused lower levels of mathematics teacher efficacy. Furthermore, these preservice teachers did not relate their

concerns about teaching mathematics to their lack on content knowledge. Prior research looking at low levels of mathematics teacher efficacy would point towards mathematics anxiety as being a potential cause, but these preservice teachers instead brought up larger pedagogical concerns about their teaching, such as differentiating their instruction, and the fear of reverting back to poor teaching practices when confronted with struggle. This finding could indicate that not all preservice elementary school teachers with low levels of mathematics teacher efficacy are necessarily worried about the content, rather, they could be worried about the larger demands of teaching.

### 6.3 How are Varying Levels of Mathematics Anxiety, Mathematics Teaching Anxiety, and Mathematics Teacher Efficacy Experienced?

Focusing on the research question "how are varying levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy experienced in elementary school preservice teachers in Ontario", the quantitative analyses, qualitative analyses, and portraiture together yield insight into the varying levels of these constructs and how they were experienced in preservice elementary school teachers in Ontario. Mathematics anxiety and mathematics teaching anxiety has been shown to be positively correlated (Adeyemi, 2015; Haciomeroglu, 2014; Peker & Ertekin, 2011; Unlu, Ertekin, & Dilmac, 2017; Hadley & Dorward, 2011). This correlation falls in line with the findings of this dissertation. The qualitative analysis shows that preservice teachers with low mathematics anxiety are comfortable leveraging their mathematical knowledge providing a level of comfort in their teaching giving them lower levels of mathematics teaching anxiety. Preservice teachers with high levels of mathematics anxiety reported working harder before and after their teaching by preparing resources beforehand and reflecting on their teaching afterwards. This work before and after

teaching helps mitigate their mathematics teaching anxiety, but these preservice teachers still reported feeling anxious during their teaching. Additionally, the positive correlation between mathematics anxiety and mathematics teaching anxiety is further supported by the quantitative results.

Mathematics teaching anxiety and mathematics teacher efficacy has been shown to be negatively correlated (Peker, 2016) in preservice elementary school teachers. This result is echoed in the work done in this dissertation. Preservice elementary school teachers with high levels of mathematics teaching anxiety had lower levels of mathematics teacher efficacy, as indicated by the quantitative results. In the qualitative data preservice teachers reported a reliance on resources. This reliance on resources indicates preservice teachers are not confident in their own teaching ability and therefore have prioritized their teaching focus on the utilization of resources. Conversely, preservice elementary school teachers with low mathematics teaching anxiety had higher levels of mathematics teacher efficacy, as indicated by the quantitative results, and shared instances of overcoming early teaching obstacles early in their teaching. This overcoming of obstacles shows a perseverance and confidence in their ability to teach and impact their students which confirms higher levels of mathematics teacher efficacy.

Past research has shown mathematics anxiety and mathematics teacher efficacy to be negatively correlated (Gresham, 2008; Swars, Daane, & Giesen, 2006; Unlu, Ertekin, Dimac, 2017). Interestingly, the results from this dissertation do not align with prior research. Preservice elementary school teachers with high mathematics anxiety reported feeling confident about their abilities to teach and impact their students. These preservice teachers believed they could push through their anxieties and still model positive attitudes towards mathematics and learning mathematics. Additionally, the preservice elementary school teachers with low mathematics

anxiety had considerably different experiences in terms of mathematics teacher efficacy. One preservice teacher indicated that their comfort with mathematics was a crutch for them to lean on when teaching was tough. This preservice teacher with low mathematics anxiety believed they were able to utilize this low anxiety towards mathematics to benefit their teaching. Conversely, the other preservice teacher with low mathematics teaching anxiety reported their comfortability with mathematics to be a hinderance to their teaching. This preservice teacher believed they could not relate as well to a struggling student and therefore reported having lower levels of mathematics teacher efficacy. The quantitative results from this study mirrored this finding as there was no correlation found between mathematics anxiety and mathematics teacher efficacy.

The quantitative and qualitative results from this dissertation come together and support the conclusions made regarding how mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy are experienced amongst these preservice elementary school teachers in Ontario. While the experiences are unique to the individual, patterns still emerge in both the quantitative and qualitative analyses. The discussion above mixes these data sets to provide evidence of these findings.

## 6.4 What Role Does Mathematics Anxiety, Mathematics Teaching Anxiety, and Mathematics Teacher Efficacy Play?

Looking at the three constructs that were examined, namely, mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy, we can see that there are subtle, yet important interactions and relationships happening amongst them. Most notably, there appears to be an argument to be made for mathematics teaching anxiety being an important piece of the conversation of preservice elementary school teachers and their beliefs towards teaching mathematics. The outlook of the landscape now points towards mathematics anxiety being

focused on the concern preservice elementary school teachers have with the mathematics content whereas mathematics teacher efficacy is focused on the concerns preservice elementary school teachers have with the mathematics pedagogy. The literature to this point has shown a negative correlation between the two, but there is evidence in the present study from preservice teachers that contradicts this notion. For example, there were preservice teachers with high mathematics anxiety who still displayed high levels of mathematics teacher efficacy.

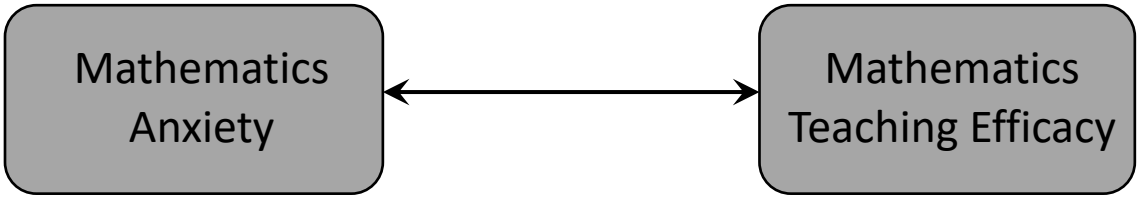


*Figure 11.* Relationship between mathematics anxiety and mathematics teaching efficacy as observed in prior research.

The understanding of mathematics anxiety and mathematics teacher efficacy in the current literature looks like Figure 11 where mathematics anxiety is correlated (negatively) with mathematics teaching efficacy. The work of this dissertation introduced mathematics teaching anxiety and looked at its interaction with these other two constructs. An initial hypothesis was that these constructs would all interact with each other and have strong influence over each other. This sort of relationship could be explained by a model like Figure 12. In this model each construct influences the other. This aligns with prior research showing the negative correlation between mathematics anxiety and mathematics teacher efficacy, but this does not align with the results of this study showing no correlation between mathematics anxiety and mathematics

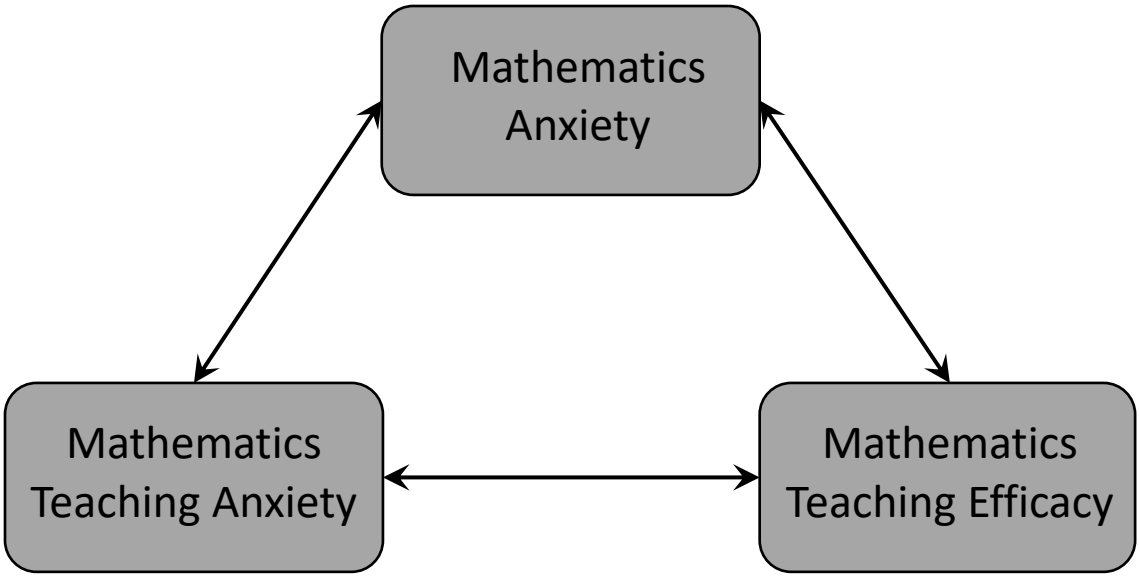


*Figure 12.* First proposed relationship between mathematics anxiety, mathematics teaching anxiety, and mathematics teaching efficacy.

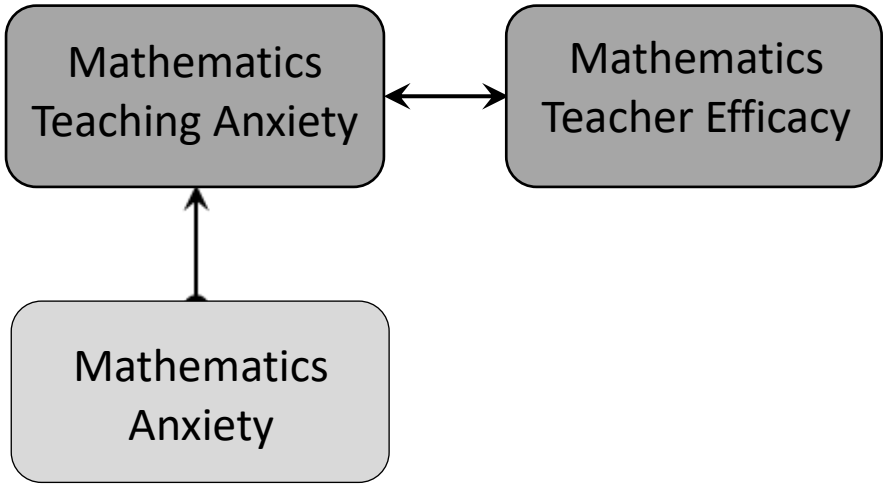


*Figure 13.* Second proposed relationship between mathematics anxiety, mathematics teaching anxiety, and mathematics teaching efficacy.

teacher efficacy. Instead, what I propose is a relationship similar to what is shown in Figure 13. 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 which shows mathematics anxiety having a negative correlation with mathematics teacher efficacy.

As I have outlined throughout this research, mathematics teaching anxiety is often overlooked and conflated with mathematics anxiety. It is routinely the case that the research questions of a study measuring mathematics anxiety are better aligned with mathematics teaching anxiety instead. I believe that the correlation between mathematics anxiety and mathematics teacher efficacy observed in prior research is actually a measurement of the correlation between mathematics teaching anxiety (conflated with mathematics anxiety) and mathematics teacher efficacy.

When mathematics teaching anxiety is introduced as a distinct and separate construct from mathematics anxiety, we get a better representation of what is happening with preservice elementary school teachers. Figure 13 shows that mathematics anxiety (when separate from mathematics teaching anxiety) has no correlation to mathematics teacher efficacy, instead mathematics teaching anxiety is correlated to mathematics teacher efficacy. This doesn't completely discredit mathematics anxiety and its impact on mathematics teacher efficacy as extremely high or extremely low levels of mathematics anxiety could impact mathematics teaching anxiety therefore impacting mathematics teacher efficacy, but the main connection is between mathematics teaching anxiety and mathematics teacher efficacy.

## 6.5 Limitations of the Study

There are some limitations of this study that are important to acknowledge in order to help the reader interpret the results. First, the participants of this research are from only six of the 12 universities across Ontario that offer a teacher education program. This was due to either a

lack of response from the universities, an inability for instructors to distribute the survey instrument due to time constraints, or a refusal to distribute the survey. 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. The preservice teachers interviewed were predominantly white and identified female. This leads to an underrepresentation of the experiences of marginalized populations because the voices of marginalized preservice teachers are unheard in the in-depth interviews. An additional aspect to this limitation is the unknown nature to what extent the participants in the questionnaire identified themselves as a marginalized person because this demographic question was not asked. Third, in order to categorize the participants as high, average, or low in all three constructs (mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy) the participants were categorized in relation to the sample population. Because of this categorization, interpretations may be biased if the sample population is skewed. This method of group categorization was done as there were no explicit benchmarks for high, average, or low for any of the three constructs in the literature.

Finally, teacher education programs in Ontario differ in on important respects. Some programs are comprised of two two-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. Additionally, acceptance from the research ethics boards at the varying institutions was received at different points of time (for example, some were a three month difference from first acceptance to last acceptance). This led to the questionnaire being administered over a three-month period as opposed to all at the same time. These factors

led to potential differences in teaching experience possibly influencing levels of mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy.

## 6.6 Suggestions for Future Research

While conducting this research it became immediately apparent that there is a lack of research on mathematics teaching anxiety in preservice and in-service teachers. It is also important to note that current research on mathematics anxiety in the Canadian context is surprisingly non-existent. This research shows a lot of promise for preservice teacher mathematics education and gives valuable insight into how mathematics anxiety, mathematics teaching anxiety, and mathematics teacher efficacy influence the mathematics classroom.

For future research I believe a push should be made to move this research from preservice to in-service teachers. The preservice teachers in this research are only able to reflect on their practicum experience (which is guided and supported by an associate teacher) and how they intend to teach in their future classrooms. Continuing this research with in-service teachers would allow for a look at what is happening in the classroom and impacting students.

Additionally, I believe this research into mathematics teaching anxiety would be useful for secondary school mathematics preservice teachers in addition to elementary school preservice teachers. In Ontario, to teach at the secondary school level preservice teachers are required to have a minimum amount of post-secondary education in their teachable subject. It is not unreasonable to assume this prerequisite would eliminate or at least mitigate issues with mathematics anxiety or mathematics teaching anxiety. Anecdotally, through my time working with preservice secondary school mathematics preservice teachers I have come across many preservice teachers who still feel uncomfortable with mathematics. Often these preservice teachers have mathematics as their second teachable (requiring a lower amount of post-

secondary mathematics courses as a prerequisite to teach) and are hoping to teach their first teachable subject instead of mathematics. I believe that because of the prerequisite of some amount of post-secondary mathematics education, the population of secondary school preservice mathematics teachers is underrepresented in mathematics anxiety research.

Finally, it is important to acknowledge that the evidence provided in this research is self-reported. With in-service teachers there is the possibility to have in-class observations of the teaching that is happening in the classroom. With in-class observations a researcher could observe phenomenon that is occurring unbeknownst to the teacher and would therefore be missed in the self-reported data. I believe this would be an interesting and important next step for this research.

## 6.7 Conclusion

A student's success in mathematics is largely determined by the quality of teaching they receive. With the recent decline in the mathematics scores from the EQAO results and the growing demand employers are putting on mathematical skills, the need to support and improve future teachers' ability to teach mathematics is high. Many preservice elementary school teachers deal with an aversion to teaching mathematics while some have an aversion to mathematics in general. Teacher educators need to continuously find better ways to identify and help preservice teachers effectively and efficiently teach mathematics to their elementary school students.

With the results of this study, it would be a bold conclusion to assume that mathematics teaching anxiety has a greater impact on teaching than mathematics anxiety, but given the amount of research showing the impact mathematics teacher efficacy has on teacher effectiveness and student learning, it is powerful to see that mathematics teaching anxiety has a greater impact on mathematics teacher efficacy than mathematics anxiety. With this knowledge I

argue that teacher educators should focus their attention on mathematics *teaching* anxiety not mathematics anxiety. Preservice teachers are resilient, resourceful, and have found ways to overcome their mathematics anxiety. Instead, we should be looking at those that are nervous to teach mathematics, not to study it. I believe this shift in perception would greatly improve preservice teaching and ultimately benefit their elementary school students.

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## Appendix A

Interview Protocol

**Time of Interview:**

**Date:**

**Place:**

**Interviewer:**

**Interviewee:**

**Intro and Description of Research:**

Thank you very much for coming today. The purpose of this study is to look into the experiences preservice teachers have with teaching mathematics and the anxiety a teacher may or may not feel when teaching mathematics. The responses you give today will be transcribed and I will be looking over them to pick out key themes that emerge from our conversation. Before conclusions are gathered from the data collected, I will be in contact with you to make sure any comments or feelings that emerge from this data are accurate to what you were trying to convey. Your identity will be kept confidential. This interview will be recorded and is expected to take approximately one hour. When you are ready we can begin.

**Questions:**

**1**. Thinking back about yourself as a student, how would you describe your relationship with mathematics? *Purpose: How do they feel about themselves as a mathematician? (Mathematics anxiety / efficacy).*

- **(mathematics anxiety)** Do you remember any feelings of anxiety surrounding mathematics?
- **(mathematics efficacy)** Did you feel confident in achieving the results you set out to achieve?

**2**. Thinking about yourself now as a future teacher, how would you describe your relationship with mathematics? *Purpose: How do they feel about themselves as a potentially good mathematics teacher? (Mathematics teaching anxiety / efficacy).*

- **(mathematics teaching anxiety)** Are there any feelings of anxiety that arise when you think about teaching?
- **(mathematics teaching efficacy)** Do you believe your efforts will be effective in teaching a math class?

**3**. Do you think you need to be a "good mathematics student" in order to be a "good mathematics teacher"? *Purpose: Do they believe they need to be proficient in mathematics in order to teach mathematics? (Mathematics teaching efficacy).*

- **(mathematics teaching efficacy)** Do you believe you will be able to make a positive impact on the students given your background as a mathematics student?

**4**. What do you think attributed to your personal relationship with mathematics? *Purpose: What is their mindset towards mathematics? What do they believe is important in making an individual proficient in mathematics? (Mathematics anxiety).*

- **(mathematics anxiety)** What would be a specific instance that contributed to your current feelings towards mathematics?

**5**. What do you think contributes to mathematics anxiety in preservice teachers? *Purpose: Looking at their viewpoint on potential sociocultural issues with mathematics and preservice teachers. (mathematics anxiety / mathematics teaching anxiety).*

- **(mathematics anxiety)** Do you think their history as a mathematics student contributes to the anxiety?
- **(mathematics teaching anxiety)** Do you think having to teach mathematics contributes to the anxiety?

**6**. Do you think your relationship with mathematics will affect your teaching? Why or why not? *Purpose: Looking at their view of how their personal relationship with mathematics will come across in their teaching. (mathematics teaching anxiety / mathematics teaching efficacy).*

- **(mathematics teaching anxiety)** Do you think your anxiety/lack of anxiety will affect your teaching?
- **(mathematics teaching efficacy)** Do you think your belief/lack of belief in your ability as a mathematics teacher will affect your teaching?

**7**. Do you think your relationship with mathematics will affect your students? Why or why not? *Purpose: Looking at their view of how their personal relationship with mathematics will be transferred to their students. (mathematics teaching efficacy).*

- **(mathematics teaching efficacy)** Do you believe that the class goals for your students that you set out to achieve will be affected by your relationship with mathematics?

**8**. Have your feelings towards teaching mathematics changed over the course of this semester? If so, how? *Purpose: Getting a better understanding of how they have transitioned with experiencing mathematics as a student to having to teach mathematics. Has the preparation to teach mathematics eased their anxiety or raised it? (mathematics teaching efficacy / mathematics teaching anxiety).*

- **(mathematics teaching efficacy)** Do you feel more or less efficacious as a mathematics teacher?
- **(mathematics teaching anxiety)** Do you feel more or less anxious as a mathematics teacher?

**9**. What advice would you give to a preservice teacher who is experiencing mathematics anxiety? *Purpose: How do they view a solution to mathematics anxiety? Gives a deeper look to what they believe to be the problem.*

**10**. Is there anything else you would like to add? *Purpose: A "catch all" question at the end to see if I missed anything and to let the interviewee discuss anything that came up during the discussion that they felt to be important.*

**Outro:**

Thank you very much for your participation today. It has been extremely helpful for this research.

# Appendix B

November 29, 2018

Mr. John Bosica
Ph.D. Candidate
Queen's University
Faculty of Education
Duncan McArthur Hall
511 Union Street West
Kingston, ON, K7M 5R7

**GREB Ref #: GEDUC-935-18; TRAQ # 6025346**
**Title: "GEDUC-935-18 Using a Mixed Methods Approach to Study the Impact Mathematics Teaching Efficacy, Mathematics Anxiety, and Mathematics Teaching Anxiety has on Preservice Elementary School Teachers in Ontario"**

Dear Mr. Bosica:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled **"GEDUC-935-18 Using a Mixed Methods Approach to Study the Impact Mathematics Teaching Efficacy, Mathematics Anxiety, and Mathematics Teaching Anxiety has on Preservice Elementary School Teachers in Ontario"** for ethical compliance with the Tri-Council Guidelines (TCPS 2 (2014)) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (Article 6.14) and Standard Operating Procedures (405.001), your project has been cleared for one year. You are reminded of your obligation to submit an annual renewal form prior to the annual renewal due date (access this form at http://www.queensu.ca/traq/signon.html/; click on "Events;" under "Create New Event" click on "General Research Ethics Board Annual Renewal/Closure Form for Cleared Studies"). Please note that when your research project is completed, you need to submit an Annual Renewal/Closure Form in Romeo/traq indicating that the project is 'completed' so that the file can be closed. This should be submitted at the time of completion; there is no need to wait until the annual renewal due date.

You are reminded of your obligation to advise the GREB of any adverse event(s) that occur during this one-year period (access this form at http://www.queensu.ca/traq/signon.html/; click on "Events;" under "Create New Event" click on "General Research Ethics Board Adverse Event Form"). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example, you must report changes to the level of risk, applicant characteristics, and implementation of new procedures. To submit an amendment form, access the application by at http://www.queensu.ca/traq/signon.html; click on "Events;" under "Create New Event" click on "General Research Ethics Board Request for the Amendment of Approved Studies." Once submitted, these changes will automatically be sent to the Ethics Coordinator, Ms. Gail Irving, at University Research Services for further review and clearance by the GREB or Chair, GREB.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Sincerely,

Dean Tripp, Ph.D.
Chair
General Research Ethics Board

c: Dr. Jamie Pyper, Supervisor
Dr. Benjamin Bolden, Chair, Unit REB
Mrs. Erin Rennie, Dept. Admin.

## Appendix C

Online Questionnaire

Age

Gender

- Male
- Female
- Non-binary/ third gender
- Prefer not to say

What University do you attend for your teacher education program?

What is your undergraduate 'major' (or equivalent)?

What is your undergraduate 'minor' (or equivalent)?

How many undergraduate math courses have you completed (one semester equals one course)?

## RMARS

For each of the following items, indicate how much the situation frightens you

| | Not at all | | | | Very much |
|---|---|---|---|---|---|
| Buying a mathematics textbook | ○ | ○ | ○ | ○ | ○ |
| Watching a teacher (or student) work on algebraic equation on the blackboard | ○ | ○ | ○ | ○ | ○ |
| Signing up for a math course | ○ | ○ | ○ | ○ | ○ |
| Listening to another student (or teacher) explain a math formula | ○ | ○ | ○ | ○ | ○ |
| Walking into a math class | ○ | ○ | ○ | ○ | ○ |
| Studying for a math test | ○ | ○ | ○ | ○ | ○ |
| Taking the math section of college entrance exam | ○ | ○ | ○ | ○ | ○ |
| Reading a cash register receipt after your purchase | ○ | ○ | ○ | ○ | ○ |
| Taking an exam (quiz) in a math course | ○ | ○ | ○ | ○ | ○ |
| Taking an exam (final) in a math course | ○ | ○ | ○ | ○ | ○ |
| Being given a set of numerical problems | ○ | ○ | ○ | ○ | ○ |
| Being given a set of subtraction problems to solve | ○ | ○ | ○ | ○ | ○ |
| Being given a set of multiplication problems to solve | ○ | ○ | ○ | ○ | ○ |
| Being given a set of division problems to solve | ○ | ○ | ○ | ○ | ○ |

| | Never | Infrequently | Occasionally | Frequently | Always |
|---|---|---|---|---|---|
| I feel uncertain about my ability to improvise in the math classroom | ○ | ○ | ○ | ○ | ○ |
| Even if I had trouble answering a student's math question, I would find it easy to concentrate on questions that follow | ○ | ○ | ○ | ○ | ○ |
| I would feel anxious when preparing math lessons | ○ | ○ | ○ | ○ | ○ |
| I'm afraid students won't follow my math instructions | ○ | ○ | ○ | ○ | ○ |
| I would feel calm if the principal informed me they were coming to my math class to observe | ○ | ○ | ○ | ○ | ○ |
| I'm afraid other teachers will think I'm incompetent at teaching my students mathematics | ○ | ○ | ○ | ○ | ○ |
| I feel anxious about my ability to keep a math class under control | ○ | ○ | ○ | ○ | ○ |
| I'll be happier teaching a math class than I originally thought I would be | ○ | ○ | ○ | ○ | ○ |
| I feel I will be less competent in the math classroom than other preservice teachers in my teacher preparation program | ○ | ○ | ○ | ○ | ○ |
| I would be afraid to speak up in the staff room | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| The thought of holding parent-teacher conferences makes me feel panicky | ○ | ○ | ○ | ○ | ○ |
| I feel certain I really want to be a teacher | ○ | ○ | ○ | ○ | ○ |
| I feel certain about my ability to keep the class interested during a math lesson | ○ | ○ | ○ | ○ | ○ |
| I would find it difficult to admit that I don't know the answer to a math question that a student asked | ○ | ○ | ○ | ○ | ○ |
| I'm worried whether I will find teaching a satisfying profession | ○ | ○ | ○ | ○ | ○ |
| I feel that I am as good at teaching math as the other preservice teachers in my program | ○ | ○ | ○ | ○ | ○ |
| I feel at ease when I am being observed by my university supervisor while teaching a math lesson | ○ | ○ | ○ | ○ | ○ |
| I'm afraid I will forget everything I know when I get in front of a class to teach a math lesson | ○ | ○ | ○ | ○ | ○ |
| I feel comfortable speaking about math in front of a group | ○ | ○ | ○ | ○ | ○ |
| I would feel calm and collected even when a student asks me a math question I couldn't answer | ○ | ○ | ○ | ○ | ○ |
| I feel less well prepared for teaching math than other preservice teachers in my program | ○ | ○ | ○ | ○ | ○ |

| | | | | | |
|---|---|---|---|---|---|
| I would be able to decide how to present math information in the classroom without a feeling of uncertainty | ○ | ○ | ○ | ○ | ○ |
| I would feel edgy and nervous if a students parent observed a math lesson in my classroom | ○ | ○ | ○ | ○ | ○ |
| I feel sure I can be a good math teacher | ○ | ○ | ○ | ○ | ○ |
| Good rapport with my students will be one of my strong points. | ○ | ○ | ○ | ○ | ○ |

**TSES**

Please indicate your response to the following

| | Nothing | . | Very Little | . | Some Influence | . | Quite a bit | . | A Great Deal |
|---|---|---|---|---|---|---|---|---|---|
| How much can you do to control disruptive behaviour in the math classoom? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| How much can you do to motivate students who show low interest in math school work? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| How much can you do to get students to believe they can do well in math school work? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| How much can you do to help your students value math learning? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| To what extent can you craft good questions for your students in math class? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| How much can you do to get children to follow classroom rules in math class? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| How much can you do to calm a student who is disruptive or noisy in math class? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| How well can you establish a classroom management system with each group of students in math classes? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| How much can you use a variety of assessment strategies in math class? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| To what extent can you provide an alternative explanation or example when students are confused in math? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| How much can you assist families in helping their children do well in math? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| How well can you implement alternative strategies in your math classroom? | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Contact Permission

If you agree to be a possible participant for a follow-up interview please provide your contact information below. You will be contacted by John Bosica, the researcher of this project. The interview process would last about an hour and be conducted in person or using a video char service at your convenience.

For contacting purposes please provide your name (your responses will remain confidential):

Email address:

## Appendix D

Codebook

| Code | Definition | Example |
|---|---|---|
| *Bring the passion for math* | Preservice teacher indicates that they have a passion for mathematics that they bring with them when they teach | "Oh, the kids know how much I love math, I can tell you that much." |
| *Above their peers* | A preservice teacher indicates that they feel comfortable with mathematics based on their peers feeling uncomfortable. | "I was working with somebody twice a week who had zero comfortability with math and the knowledge just wasn't there" |
| *Confidence in mathematics content* | When a preservice teacher indicates their feelings towards being prepared and comfortable with the content side of mathematics | "I feel confident in my teaching, I am only teaching up until grade six math anyways" |
| *Confidence in teaching mathematics* | When a preservice teacher indicates their feeling towards | "I think I have the ability to teach up until high school at |

| | | |
|---|---|---|
| | being prepared and comfortable with teaching mathematics. | least. That I am teaching only until grade six gives me no worries at all." |
| *Not enough time to teach* | When a preservice teacher indicates that their concern with teaching is based on there not being enough time | "The biggest challenge for me was learning how to budget your time when you teach. Be mindful of the subjects you spend time on." |
| *Worry about motivating students* | When a preservice teacher indicates they are focused on student motivation in the mathematics classroom. | "I don't know exactly how I am going to motivate students to do the work." |
| *Struggle teaching at first* | When a preservice teacher describes a situation where they hit an early stumbling block in their teaching. | "I was standing in front of a class of five- and six-year olds with a whole bunch of blank eyes." |